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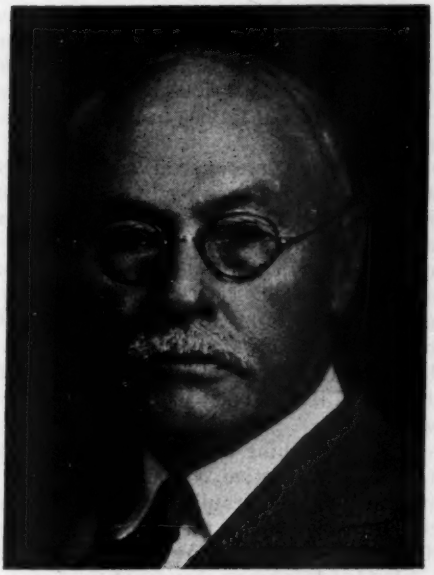
LAMME AWARD—ANSON MARSTON



ANSON MARSTON

RECIPIENT OF LAMME AWARD

To Anson Marston—for his leadership and service in the profession of engineering; for his vision and initiative in broadening engineering curricula; for his enterprise in guiding his students to a balance of engineering skill and artistic appreciation; for his foresight as a pioneer in the field of engineering extension; and for his untiring efforts in promoting closer coöperation between government and engineering colleges the 14th Lamme Medal for Achievement in Engineering Education is awarded.

ANSON MARSTON, the fourteenth Lamme Medalist of the Society for the Promotion of Engineering Education, was born on May 31, 1864, in Seward, Illinois. He was graduated from the West Rockford High School in 1883 and, after teaching for one year in the public schools, entered Berea College as a student in the Liberal

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Arts course. In 1885 he transferred to Cornell University, where he received a degree in Civil Engineering in 1889.

From the time of his graduation from Cornell University until March, 1892, Dean Marston was engaged in railroad and bridge location work in Michigan, Arkansas and Louisiana. He then joined the faculty of Iowa State College, where for a number of years he served as Professor and Head of the Department of Civil Engineering. In 1904 he became the first Dean of Engineering of Iowa State College; in 1932, the Senior Dean; and in 1937, Dean Emeritus. In the winter of 1903–1904 he organized one of the first two Engineering Experiment Stations in the United States, remaining its Director until 1932.

Dean Marston is keenly interested in educational problems and has devoted much of his time to the study and development of engineering curricula and teaching methods. One of his many contributions to engineering education was made in 1920 when he developed a course of instruction in Engineering Valuation, recognized as pioneer work in this field. Throughout the years he has continued to teach regardless of other demands on his time.

Dean Marston is the author of more than two hundred published bulletins and technical papers as well as the author of *Sewers and Drains,* published in 1915, and joint author of *Engineering Valuation,* published in 1935.

In addition to his teaching and administrative activities, Dean Marston has engaged in active consulting practice in sanitary, municipal, transportation, hydraulic and valuation problems since 1892. He served as a member of the Iowa State Highway Commission from 1904 to 1927 and as Chairman of that organization from 1913 to 1915. He has been an active member of a number of engineering boards, including the Interoceanic Canal Board (Panama and Nicaragua) in 1929, the Mississippi River Flood Control Board in 1932, Engineering Board of Review, Sanitary District Chicago from 1924 to 1928, and Florida Everglades Engineering Board of Review in 1927.

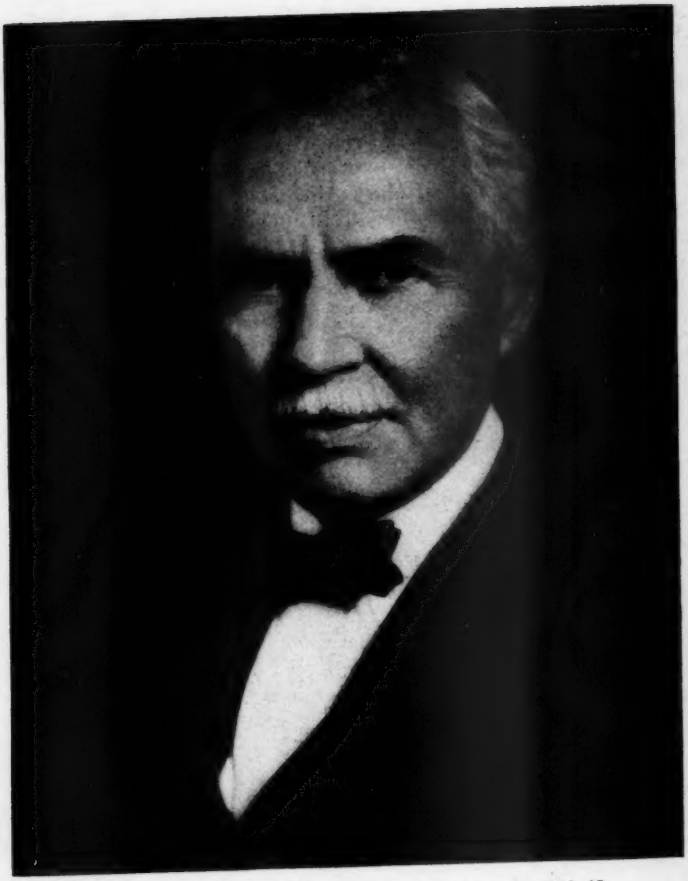
In the service of the United States during the first World War, Dean Marston held the rank of Lieutenant Colonel of Engineers. Since 1924 he has held the rank of Colonel in the Engineering Reserve Corps.

During his professional career Dean Marston has been associated with the following organizations: S. P. E. E. (Treasurer 1906, President 1915); A. S. C. E. (Director 1920–1922 and 1930–1931; Vice President 1923–1924, President 1929, Representative on National Research Council 1919–1922, Chairman of the Highway Research Board); Iowa Engineering Society (President 1909); A. S. T. M.

(Executive Committee 1914–1916 and 1924–1926); Land Grant College Engineering Association (President 1915); and American Association of Land Grant Colleges and Universities (President 1929). He is a member of Sigma Xi, Tau Beta Pi, Phi Kappa Phi, Theta Xi, Acacia, and is a Thirty-Second Degree Mason and a Knight Templar.

In recognition of the soundness and significance of his contributions, Dean Marston has received honorary doctorates from the University of Nebraska and Michigan State College, and has been awarded the Chanute Medal of the Western Society of Engineering and the Fuertes Gold Medal by Cornell University.

Dean Marston married Mary Alice Day on December 14, 1892. They have two sons, Morrill W., a Lieutenant Colonel in the United States Army, and Anson C., a member of the staff of the Kansas City Power and Light Company, now in active service as a Major in the Field Artillery Reserve.



ALFRED H. WHITE, PRESIDENT OF THE SOCIETY, 1941–42

ALFRED HOLMES WHITE, PRESIDENT, 1941–42

Alfred Holmes White, educator, chemist, and chemical engineer, is a native of Peoria, Ill. His parents were Samuel Holmes White and Jennie McLaren. The tall, white-haired gentleman, known to many generations of University of Michigan students, seems to most of them to be such an integral part of the university that it is not easy to realize that Professor White studied, or did early teaching, at McGill University, Montreal; at the University of Illinois; and at the Polytechnicum, Zurich, Switzerland, where he did graduate study under Lunge. His A.B. degree, it is true, was received at Michigan, but it was not until several years later, in 1897, that he began his long career at Ann Arbor, where he became instructor in chemical technology, his subject of specialization at Zurich. Professor White's collegiate training was in the classics and in chemistry, chemical engineering being at that time unknown.

In the summer of 1898, Alfred White, with several other young men, made a trip to the Klondike. One gathers that no great amount of gold was found, but that quite a summer was had—a summer which was decidedly nonacademic.

During his early years at Michigan, the young instructor was associated with Edward de Mille Campbell, Albert B. Prescott, Otis C. Johnson, and, as more nearly a contemporary, with Moses Gomberg. All of these men influenced Alfred White's scientific outlook and career. His early work on portland cement was done with Professor Campbell, and from this same remarkable personality his interest in metallurgical subjects stems.

During the pre-war period, Professor White moved through the usual academic grades of instructor, assistant professor of chemical engineering, professor of chemical engineering, and, since 1907, head of the department of chemical engineering.

The academic titles so listed indicate in a general way the development of chemical engineering at Michigan. A chemical engineering curriculum was set up at Michigan in 1898, located in the Engineering Department, although the training given in the course was predominantly chemical. In this point, it may be of interest to note the prediction made at the time to Professor White by Mortimer E. Cooley; namely, that A. H. White would see the day when chemical engineering would constitute the largest engineering branch at the University of Michigan. Some 35 years later, both Professor White and Dean Cooley saw the prediction verified; the reader can rest assured that the fact was duly noted by both men.

As chemical engineering grew, and as the program of training developed, Professor White accepted greater and greater propor-

tions of the responsibility of the course and, in 1907, became head of the Chemical Engineering Department, taking over the headship from Professor Campbell, who, in turn, completed his career as the director of the Chemical Laboratory.

During the entire history of the Chemical Engineering Department, metallurgy has been associated with it, first under Campbell and later under A. H. White.

During the leisurely pre-war days at Ann Arbor, Professor White carried out fundamental work on portland cement, gas and fuel analysis. Perhaps his best-known and most important work on portland cement was his demonstration of the net volume increase of portland cement resulting from alternate wetting; test bars representing a wide variety of cement types and mixes were prepared with glass-end plates allowing accurate measurement of length. The data obtained from the periodic measurement after controlled wetting and drying of these bars during more than 30 years have shown the importance and extent of volume changes in portland cement.

In reviewing Professor White's career, it is noticeable that the World War of 1914–18 formed a pivotal point. The war brought him suddenly into a type of activity which differed from anything he had known before. Early in the emergency, he applied to the War Department for a commission and was appointed a captain in the Ordnance Department and first assigned as head of the Metallurgical Branch of the Inspection Section of the Gun Division. He held that post until the middle of September, 1917, when he was transferred to a new division (Division T) created to take care of the production of raw materials for explosives. He became technical adviser to the military head of the department, Colonel J. W. Joyes. He was stationed in Washington throughout the war and acted as technical director of the Nitrate Division. He had great influence in the development of the plans, processes, and operations of the Muscle Shoals Nitrate Plants. He was at first commissioned captain, but later became a lieutenant colonel.

Colonel White held a position of considerable authority in the Nitrate Division. The $100,000,000 industrial effort to be put through in rush time was, of course, no easy task. There were necessarily entanglements with other branches of the War Department, there was red tape to be cut, and a large organization to be kept in line. The Colonel also had to act as a buffer between the military organization above him, and the nonmilitary, highly trained technical men, who did not always respond to military restrictions, below him. The plants were constructed in record time and operations were started at the time of the Armistice.

From the associates of Professor White who knew him before and after war days, the writer has received the impression that his Washington experiences did result in a moderate and conservative extension of the White vocabulary, and, more important, brought to him an appreciation of the importance of engineering factors in the large-scale operation of processes.

The writer first saw Colonel White on his return from the war. The initial impression of an urbane, dignified, genial gentleman was intensified by the fact that the Colonel was still in uniform. Professor White's post-war associates and students undoubtedly have these same impressions. He seems to be on a permanent plateau as far as age is concerned. Recently the alumni of the Chemical Engineering Department of the University of Michigan had his portrait painted.

Since the war, Professor White has not only witnessed the growth of modern chemical engineering generally, but under his administration his own department has developed in size and reputation to front rank. The great increase in graduate work, the emphasis on research, the close contacts with industry, are all important basic principles that have been operative in the development of his department. Professor White has during this period been influential in the policies of the Engineering College as a whole.

Since the inception of the Department of Engineering Research, which is a successful agency in correlating the industrial research work in the Engineering College, he has been one of its most active supporters and has had a great influence on its policies and progress.

Much of Professor White's post-war professional activity has been centered around the American Institute of Chemical Engineers, which owes a great deal to the time, thought, and energy he has devoted to its affairs. A member of the institute since 1914, he served as director in 1922 and 1923; as vice president from 1924 to 1928; and as president in 1929 and 1930. The first student chapter of the institute was formed under the guidance of Professor White at Michigan in 1922.

Professor White's personal and home life has been that of a cultured gentleman and good citizen. He served as a member of the Ann Arbor City Council; he has taken a lifelong interest in civic, state, and national affairs. His hobbies have centered around reading and gardening. His fund of quiet good humor makes him an excellent companion. He married Miss Rebecca Mason Downey, of Pueblo, Colo., in 1903. The home life of Alfred and Rebecca White has centered around two children: the late Dr. Alfred McLaren, whose untimely death in 1936 cut short a career well started; and Dr. Mary Julian, a practicing New York physician.

WARREN L. MCCABE.

THE PAST YEAR

By ALFRED H. WHITE

President, 1941–42

Those who attended the annual meeting at Berkeley a year ago will remember the bulletins which were read at the various sessions announcing the daily progress of the program for Engineering Defense Training which was just being formulated in Washington. The recent meeting at Ann Arbor devoted several sessions to a serious discussion of what had been done in this field and what should be the attitude of the society towards the education of engineers in this time of stress. Attendance at the Ann Arbor meeting was somewhat less than two years ago at Penn. State, for many of the members were in military service, workers in defense industries, or instructors in the Engineering Defense Training Courses.

During the past year the Society has proved its value as an organization competent to represent the engineering colleges and their teachers in the discussions of the important educational problems which have arisen in connection with national defense. The United States Commissioner of Education was quick to recognize the valuable aid which the Society could give. President Prentice and Secretary Bishop took part in many official conferences in Washington. Past-president Seaton became director of Engineering Defense Training and past-president Potter was retained as consultant in the work. Both of these men as well as Dean Case presented papers at the Ann Arbor meeting, and their reports are published in this number of the JOURNAL.

The engineering colleges have responded to the challenge wholeheartedly and with good judgment. They have not let themselves be carried away by hysteria and have not shortened their regular programs at the expense of thoroughness of training. They have however added short courses designed to train men for specific positions in the defense industries. The work has been eminently successful as was shown by the reports at the Ann Arbor meeting.

The army and navy have both called reserve officers for active service, and the civilian administrative bureaus in Washington and the emergency research programs have also drawn upon the staffs of the engineering colleges. It is right that these men should

give their services where they are most needed. The government has however recognized that the staffs of engineering colleges must not be depleted dangerously, and the War Department has set up a pool of reserve officers who are not to be called to active duty, but are to be allowed to continue their present work because of the importance of their civilian duties. Some of the key teachers who are also reserve officers have been retained in the colleges through this wise provision.

The colleges have had to assume the burden of the Engineering Defense Training Courses as an added load on a depleted staff. It has sometimes been possible to secure instructors for evening courses from men working in industry but capable men have usually been already working overtime, and, for the most part, the college teacher has had to add a burden of evening teaching to his increased daytime load. The teachers of the engineering colleges are greatly to be commended for their willingness to sacrifice their leisure, their research work and their time for study in order to carry the additional teaching load. They have, in a very real sense, sacrificed their preparation for their own advancement to the immediate need of their country.

The coming year may call for even greater activity on the part of the engineering colleges. Certainly the estimates of the number of skilled workers, engineers and scientists who will be required by the army and navy are staggering. Perhaps the students in the regular session will be fewer although this is questionable. The need for engineers has been so widely advertised that many boys will be attracted to our profession. The action of the draft boards in granting deferment to engineering students will prevent wholesale loss of students to the military services. Some of the upper classmen will be attracted by the offer of good jobs and will plan to stay out a few years and return after they have saved enough money to let them finish their courses without having to earn money as they go. Graduate students will be fewer. The demand for Engineering Defense Training Courses will be larger, and the total effort of the engineering colleges will almost certainly be greater even if the number of regular students is somewhat less.

After hearing the discussions at the Ann Arbor meeting the Council of the Society adopted the following resolution:

WHEREAS, during the past academic year the engineering colleges of the Nation have responded to the call to aid in the national defense by adding to their regular programs of instruction the training of large numbers of special students under the Engineering Defense Training program:

Be it resolved **that the Council of the Society for the Promotion of Engineering Education reaffirms its support of similar measures which may be undertaken in addition to the normal programs of engineering education that are demonstrating their effectiveness in the present emergency and, we believe, will prepare for the period of reconstruction when the emergency shall have passed.**

The engineering colleges have been called upon to make a major contribution to national defense. They have responded nobly, and will continue to meet the demands which will be made upon them.

SAFETY ENGINEERING DEFENSE TRAINING

By ROY A. SEATON *

Pressure for defense production is causing a marked increase in the toll of industrial accidents, and in the need for training in the principles and practices of safety engineering. Thousands of new workers are being employed who are unfamiliar with factory hazards, and working space is becoming more crowded. The inevitable result will be a large increase in wasted manpower and lost production unless effective preventative measures are taken.

During 1940, labor wastage because of work injuries is reported to have increased 10 per cent, while employment rose only 6 per cent for the country as a whole. In many individual industries the disparity between increased accident and employment rates was much greater. For that year, it is stated, the total production loss through industrial accidents was approximately 1½ billion man-hours, enough to build from 15,000 to 18,000 large bombers; 30,000 medium bombers; 75,000 to 90,000 fighter planes; 450 submarines; 375 destroyers; or 45 battleships. For every man-day of idleness due to strikes, four days were lost through accidents. Pressure on industry by our defense effort is now much greater than it was in 1940, and it will continue to increase.

Experience has demonstrated that a large proportion of such accidents can be prevented by the application of known and tested techniques of industrial safety, and by safety training. The reduction has been as high as 90 per cent in many industrial companies. Safety techniques and safety training for defense differ from those needed in normal times only in the extent of the need and its urgency.

To emphasize the necessity for accident prevention measures in defense industries, and to assist in making them effective, the U. S. Department of Labor has organized a National Committee for the Conservation of Manpower in Defense Industries. Members of this committee, who serve on a voluntary basis, represent private industry, organized labor, safety organizations, and several federal and state agencies concerned with the problems of industrial health and safety. Under the general supervision of this committee industrial safety experts in all parts of the country, serving without compensation, will make direct contact with industrial units en-

* Dean of the Division of Engineering and Architecture, Kansas State College, absent on leave to serve as Director of Engineering, Science and Management Defense Training in the U. S. Office of Education.

gaged in defense production and will assist them in setting up individual safety programs designed to—

1. Prevent the maiming, killing, and injuring of trained workers;
2. Prevent the loss of valuable production time through sickness, accidental injury, and occupational disease;
3. Prevent disruption of and delays to production schedules, damage to machines and equipment, and wastage of materials which follow in the wake of accidents;
4. Control, insofar as possible, all environmental factors which may render the worker less fit for the job of maintaining quantity and quality production.

As part of this effort, a Planning Subcommittee on Safety Defense Training has been formed to foster the development of safety training programs for defense industries. The Society for the Promotion of Engineering Education is represented on this committee by Secretary F. L. Bishop, and the Engineering, Science, and Management Defense Training program is represented by the writer.

The underlying purpose of Safety Engineering Defense Training is to assist the defense industries by training key supervisory employees who have the responsibility for maintaining the safety, health, and efficiency of the workers. It is expected that these supervisors will, in turn, instruct the workers through company training programs and will sponsor such revisions in plant layout and procedures as may be necessary to protect the workers.

Engineering colleges offer a logical medium for Safety Engineering Defense Training for key supervisors, and the E. S. M. D. T. program provides a practical means for organizing it. The E. S. M. D. T. staff is actively coöperating in this project. Suggested course outlines are now being prepared for the guidance of institutions planning to give such courses, and most or all of the 22 E. S. M. D. T. regional advisers have accepted invitations to serve as regional advisers to the regional and local representatives of the National Committee and its Subcommittee.

It is gratifying to note that the need for instruction in safety engineering was recognized early in the E. D. T. program by a number of institutions, and that such courses have already been given or are now nearing completion at the University of Pennsylvania, Lehigh University, Purdue University, Alabama Polytechnic Institute, the University of Notre Dame, Illinois Institute of Technology, and the University of Minnesota. The experience thus gained will be very helpful in planning the expanded program now contemplated.

SCIENCE AND TECHNOLOGY IN THE ENGINEERING CURRICULA*

By D. B. PRENTICE

President of the Society; President, Rose Polytechnic Institute

In comparison with the presidential addresses before recent conventions of this organization the present effort must inevitably seem a discussion of the commonplace. For in this annual session we turn from the economic, social and spiritual aspects of technical education, to which we have given much consideration in the past decade, and re-examine the fundamental training upon which rests, for our graduates, all hope of success as professional engineers. No apology is made for this re-examination.

We recognize indubitably the potential significance of the engineer's part in modern society. We gladly assume our responsibility for teaching the social and economic obligations which fall upon those who advance technology. We submit, however, that without sound technical training our graduates will not disturb the social order with any impressive advance. For the current week, therefore, we return to fundamentals. "Let not things, because they are common, enjoy for that the less share of our consideration."

It has been said that "the only permanent characteristic in life is change." The statement has a challenging sound of inconsistency and appeals particularly to scientists and engineers. And of course it is almost true. In the past half century change has been more extensive and more rapid than in any period of history of equal length. Being human and therefore readily adaptable, we are apt to forget the range of experiences through which we have lived and the readjustments we have been compelled to make.

In the field of urban transportation, for example, we have seen the horse-car followed by the electric and that in turn supplanted by the motor bus. In longer range transportation steam locomotives have been replaced in part by Diesel or electric engines. The steam automobile has come and gone as has the car driven by a two-cycle gasoline engine. The electric battery vehicle is nearly extinct. The four-cycle source of power has grown from one to a dozen cylinders. (You recall when we could count the explosions per

* Presidential Address delivered at the 49th Annual Meeting, S. P. E. E., University of Michigan, June 23–27, 1941.

city block.) From the first timid experiments we have seen heavier-than-air flying machines developed into reliable conveyances.

Electric lighting, long distance telephony, wireless communication, motion pictures, plastics, air conditioning and mechanical refrigeration are barely an introduction to the long list of technical achievements of our generation. Illustrations of change and progress can be multiplied almost endlessly and in every division of technology. As teachers we recall vividly the recurring editions of text-books and the perennial curriculum revisions by which we have endeavored to keep our engineering instruction from falling too far behind current practice.

These paragraphs were not written to imply that there has been no parallel change in the underlying, fundamental subjects of our engineering curricula and that technical applications, only, have altered. Many of us remember well when the atom was the limit, and the differentiation between chemistry and physics was reasonably well marked. Change has been as characteristic of science as of engineering and we are forced to return nearly to the law of signs or functions of an angle to discover identity between the courses we took and the courses we teach.

The impact of change has been so sharp and has been brought so bluntly to our attention by the demands made upon our graduates that we have, I fear, too often concentrated on meeting the changes and have neglected to pay deserved attention to the simple verities underlying the science and technology in our curricula. The result, some years ago, was a motley collection of specific applied courses in the second half of our four-year program. All of us can recall separate credits in such restricted topics as valve-gears, cam design, stereotomy, hydraulic motors, arches and similar specialties.

The pressure of extended and varied applications (trying to keep up with the Joneses academically) plus the enlargement of elementary courses, plus the introduction of economic and social considerations finally drove the specialized subjects from the undergraduate program. The industrial customers for our student product hastened the elimination by assuring us repeatedly that men soundly trained in fundamentals were more acceptable than those with an assortment of smatterings. Of course an education in semi-obsolete procedure was a handicap, and the engineering colleges found it nearly impossible to keep teaching material abreast of professional practice.

It is not the purpose of this paper, however, to elaborate on these curricular changes. The purpose is rather to question the treatment accorded those unspectacular sections of science and technology which are fundamental, which have not been disturbed

by recent research, which are as true today as when engineering colleges first enrolled students. For in the continuous effort to incorporate new material in our courses I believe we have not had, or taken, time to give due consideration to the old. This is a sweeping generalization and, like all such statements, has exceptions. No doubt many of us can recall original and stimulating teachers who introduced novel and refreshing methods of instruction in their class rooms. Probably most of you belong to this group. I believe, however, that such men are exceptions and that in general the teaching of the old established fundamental science and technology should receive more attention than has been paid it in recent years. "Laissez-faire" is a tempting response which mathematicians, scientists and technologists must refuse to give. There is always a sense of security and comfort in following the familiar well-travelled highway, but the stimulation of new scenery is frequently discovered only by risking the bumps of a new route.

The writer has no illusion of being competent to announce desirable revisions. All that he can attempt is to present some pertinent questions for the consideration of those long familiar with, and thoroughly experienced in, the teaching of the subjects which underlie engineering education.

With the exception of periods assigned to discussions of the engineering defense training program, the principal sessions and conferences of this annual meeting will be devoted to these problems. At the general session on Thursday morning well-qualified speakers will report on modern methods and materials of instruction in four fundamental subjects, mathematics, chemistry, physics and mechanics. It is the hope of your executive committee that extended discussion of "science and technology in the engineering curricula" will have an important place in your conferences.

With the humility proper for an engineer under the circumstances, or with the temerity characteristic of an engineer under the circumstances, according to your point of view, I venture to suggest some problems which I believe deserve earnest consideration at the present time, regardless of how frequently they may have been under discussion in the past.

Of the mathematicians I would ask: what must the engineering colleges offer to compensate for the inadequate mathematical preparation which so many of our students now receive before admission? What proportion of the total time available for mathematics should be allocated to analytic geometry and what topics should be taught under this title? Do the results achieved in so-called laboratory periods for supervised problem-solving justify the extra schedule assignments for students and faculty? Should a course in differential equations be required for every undergraduate? Should the

teaching of mathematics to engineering students be intensive or extensive? Do we customarily include too many topics of limited application and thereby sacrifice a thorough grasp of the essentials? Some teachers of mathematics seem to feel that comprehensive courses are preferable to comprehending students. We can rely upon the mathematicians to produce the answers to these questions for "Histories make men wise; poets, witty; the mathematics, subtle; natural philosophy, deep."

To the teachers of drawing I would again propose the question, even after the years of discussion it has received: what is the objective of the course in descriptive geometry and is it being reached? In some colleges descriptive geometry is introduced painlessly and anonymously under the designation of engineering drawing. No distinction is made between a top view and an H-projection. In other colleges descriptive geometry is an independent and impressive course. A graduate of such a course, now a successful architect, recently remarked that the way to produce an architectural engineer is to take a civil engineer and really teach him descriptive geometry.

Of the teachers of physics I would ask: how much of the general course for engineering students should be allotted to light and sound? Should the physics faculty insist on a large share of mechanics, heat and electricity, or leave the major part to later courses in engineering departments? In other words, how much repetition is desirable or necessary? Are routine laboratory experiments, such as, for example, the determination of the specific heat of copper, worth while for the teaching of research technique and observation, and for practice in preparing reports, or would the time be better spent on problems which might stretch the students' minds? To what extent, if any, should motion pictures be instruction material?

There are many questions which might be presented to the teachers of mechanics. For instance, should there be separate courses in mechanics of materials and applied mechanics, as promised in certain catalogs, or are these properly one course? How far is it safe to emphasize the similarity of a bridge truss, a 2×8 floor beam, and a cam shaft? What division of time between statics and dynamics is wise for electrical and mechanical students? Should the calculus be emphasized or minimized? Must all problems be stated in foot-pound-second units or is it fair to confuse the students with c.-g.-s. dimensions? Should there be a separate course in mechanisms or kinematics, or do these topics belong in mechanics? Are lectures in mechanics worth giving, and if so, should they be accompanied by experimental demonstrations, or should the entertainment features be omitted after sophomore phys-

ics? After all, is there any other way to learn mechanics except by doing problems and then doing more problems?

Of the chemists I hardly dare ask a question. I am not certain, today, of what is chemistry. A debate on the line of demarcation between chemistry and physics would be enlightening if not too dangerous. It would be illuminating, too, to hear a member of the profession demonstrate the proposition that general chemistry for non-chemical engineers should be restricted to a course in the chemistry of engineering materials.

A presidential address, I presume, should be something more than a collection of question marks. Meeting that requirement on the subject of this annual meeting involves an engineer in a precarious situation. But once upon a time the speaker rated the honor section in mathematics after a term in analytics under Percy F. Smith, and with the encouragement of that long-past achievement he would venture a few mild comments on the major problems confronting mathematics departments in engineering colleges today. And even from limited experience:

> To observations which ourselves we make
> We grow more partial for the observer's sake.

All questions relative to science and technology in the engineering curricula catalog in two groups, one dealing with material and the other with method. The earliest problem facing the mathematics department is one of material; considering the frequency of inadequate high school preparation how much review should be required?

A cold blooded answer is "none." That policy would sacrifice some potentially successful engineers. Many freshmen lack a conception of real mathematics through no fault of their own. The lack can be met by pre-admission courses *at* the college or by summer correspondence courses *from* the college provided the students' deficiencies are discovered. But high school grades are not reliable evidence of genuine accomplishment and most engineering colleges cannot insist on entrance examinations. A second solution is the non-credit course to which students are assigned after two or three weeks of review work in regular sections have disclosed their weaknesses. This is probably a more satisfactory solution. It postpones the usual mathematics of the freshman year and requires a summer session before the sophomore year to close the gap. However the other courses customarily offered in the first year are not seriously handicapped by this delay and the plan is certainly preferable to a losing struggle with the regular mathematics.

When an instructor knows provision has been made for promising but poorly prepared students he is much less reluctant to drop

them from his classes. When the students realize that through a non-credit course they have an opportunity to master the material which should have been mastered in high school and that later they can recover standing in a summer session, they are usually willing to accept the instructor's recommendations. Undoubtedly mathematics instruction has slipped in many preparatory schools; dramatics, library science and the band are more interesting. The engineering colleges have no choice, it seems to me; they must recognize and replace the shortage.

The question of intensive vs. extensive courses is again one of material. I venture to assert that at least seventy-five per cent of the mathematics courses in engineering colleges are too extensive for the time allowed. There seems to be a pride among some mathematics teachers of coverage rather than of completeness. These men describe their courses by listing the topics discussed and the longer the list, the better, by implication, the course. I am still waiting to hear a mathematics professor say, "We cover only the more important topics in the text, those which have fairly common applications in engineering; but by the end of the year a student must be able to set up and solve correctly at least eighty per cent of any problems our engineering staff sends us." Eighty per cent is used advisedly for as Isaac Walton wrote: "Angling may be said to be so like the mathematics that it can never be fully learnt." The intensive method of instruction might fail to produce mathematicians, but it would certainly equip the engineering student with a tool sharp enough for steady use.

At several leading engineering colleges analytic geometry is gradually fading from the picture. This seems reasonable; and it will never entirely disappear. One afternoon I discovered a young man in our college reading room who was struggling with the equation of a line, from a point without, which will be tangent to an ellipse. I found difficulty in explaining that knowledge of this particular bit of theory is a *sine qua non* for success in engineering.

The purpose of this address has been to draw your attention away for a while from the challenging and fascinating innovations of science and technology, back to the dull, commonplace, but fundamental and essential aspects. And the question I would leave with you is a simple problem of materials and methods. Are we selecting the right bricks and laying them correctly with the strongest mortar for these fundamental courses in the foundation of engineering education?

ADDRESSES OF WELCOME

By ALEXANDER G. RUTHVEN

President, University of Michigan

I believe I should confide in you that while I have been correctly introduced as the President of the University of Michigan, I am something else this morning. I am a worm! I am a worm that has decided that this is the time to turn. Your president explained my presence here at the beginning of the program rather than later in a very nice, attractive (and with all) truthful way. Nevertheless, there is another reason for this shift. All year long I have taken orders from the faculty. I have done what they told me to do. When they told me to come hither, I have come, and when they told me to go thither, I have attempted to do so, but I was asked some minutes ago by a distinguished member of our faculty if I would give you an official greeting this morning, and I very gladly agreed to do that.

Then last night I picked up the program and found out that you were going to be greeted by almost everyone else and that I was down here for an address, and I thought it was just about time that the worm turned. Seriously, there isn't anything that I can say to you that you do not appreciate as well as I do. I can assure you, however (and I mean it in no merely perfunctory way or sense), that we are delighted to have you with us this year. You are even more welcome than you would have been at any time I can think of in the past. This is the time when we must all have very great concern for education.

In the midst of the commencement exercises last week I received a very urgent invitation to come to Washington the latter part of this month and take part in the nation-wide broadcast on the general question "Can Education Survive Another War?" Is it possible for education to survive another war? Well, that is a curious question. It can be discussed in many different ways from many points of view. I don't think it is properly phrased, but nevertheless we will have to admit that war periods are very disastrous to educational programs and educational institutions. I believe you will agree with me that our educational institutions have not yet recovered from the effects of the first World War. If we could have a conference on this matter, you and I both could point out the many things that we might have done in this period since the

last World War that we have been unable to accomplish because of the things that happened immediately following that period.

I very seriously doubt that education—higher education at least, can survive intact this war period. There are going to be disastrous consequences, do the best we may, but this is no reason why we should feel hopeless, why we should simply accept the situation. I also believe that if we can come together in meetings such as those you are holding, if we can get set before ourselves the objective of holding our education program, if I may so express it, on a even keel, we shall be doing a tremendous service for mankind.

After all, the exigencies of the present period are not the most important things confronting us. We must, as educators, in my opinion, keep firmly in mind the great responsibility which we shall have and our successors will have in the rehabilitation after this fracas is over. That means then, as I said before, that, in my opinion, we must bend every energy to keep our institutions and our programs functioning in the best possible way during this period.

By IVAN C. CRAWFORD

Dean, College of Engineering, University of Michigan

Some twenty-one years ago the Society for the Promotion of Engineering Education honored the University of Michigan by holding its annual meeting on this campus. At that time the nation was endeavoring to get back to "normalcy"—endeavoring to re-establish the old order of things as quickly as possible. Engineering teachers soon discovered that for them there could be no normalcy. First, and almost immediately, came the Investigation of Engineering Education conducted by the Society (and may I lift the basket from Michigan's light just far enough to remind you that Dean M. E. Cooley was one of the five members of the Board of Coördination and Control, and that President F. W. McNair of the Michigan School of Mines occupied a similar position).

Closely following the completion of the Investigation came the great depression. Problems of the minute claimed your attention, but not exclusively. Soon the Engineers' Council for Professional Development came into existence and in its formation the Society occupied a place of honor. Quickly the accrediting program developed, being carried to its objective through the efforts, quite largely, of this Society.

Emergencies, limited and unlimited, seem regularly to cross the trail of this Society. The latest one has brought Engineering Defense Training Courses to us. Again the S. P. E. E., as a society

and through the efforts of its members, has been equal to the occasion and has taken its accustomed place of leadership.

The University of Michigan is most happy to welcome to its campus a Society with such a distinguished record of achievement. We of the College of Engineering are delighted to have this opportunity to renew old acquaintances—to serve you in every possible way.

By LORIN G. MILLER

Professor of Mechanical Engineering, Michigan State College and chairman of the Michigan Section

This is not only a pleasure, but it is a distinct surprise. When I came on the campus, some of my friends said they were on the way in order to be able to applaud my speech, and when I got my program, I noticed I was on here.

I shall say again it is very pleasant to be with this distinguished group on the platform and to express the appreciation of the Michigan Section at having you in our midst. I am not sure that I am officially able to greet you this morning because the Michigan Section voted unanimously to forego the pleasure of having a spring meeting in order that we might concentrate on this meeting. Therefore, I should have been an ex-chairman from the Section. I am not sure who the new one is. Nevertheless, it is a pleasure to speak for the Michigan Section in welcoming you to this part of our great country.

RESPONSE TO ADDRESSES OF WELCOME

By D. B. PRENTICE

President of the Society

I want to express to you my happiness at being at the University of Michigan for this annual meeting, and to thank you most sincerely for your joint welcome. We know what the hospitality of the University of Michigan means, because, as Dean Crawford said and as you well remember (many of you through pleasant personal experience) an annual meeting of the Society was held at this university on this campus in 1920 and at another time there was a meeting of the deans and administrative officers of the Society held at the University of Michigan.

As I remarked to Dean Crawford at the Council dinner last night, the warmth of the hospitality of the University of Michigan was severely tested at the time of the meeting of the administrative

officers, because, as I recall it, the temperature on this campus outdoors was 20 degrees below zero and there must have been four or five feet of snow, but I can assure you that the warmth at the meetings was real.

There is, of course, a rather unusual association between the Society for the Promotion of Engineering Education and the University of Michigan, because Mortimer Cooley, now Dean Emeritus (and in former years dean) of the College of Engineering here, was a member of the original Committee on Engineering Education which served in connection with the World Engineering Conference, which, in turn, was part of the program of the World's Fair in Chicago in 1893. It was through the work of that committee that the Society for the Promotion of Engineering Education was organized. We all regret very much that Dean Cooley is not here this morning. We had hoped that he would at least sit with us on this platform if, perhaps, he preferred not to join in the welcome, but Dean Cooley is absent from Ann Arbor, and therefore we have to miss the pleasure of greeting him.

I assure you that we appreciate greatly your cordial welcome. We have already had examples of present hospitality, and we look forward with much pleasure to the meetings during the remaining days of the conference.

REPORT OF SECRETARY, F. L. BISHOP, 1940–41

Membership.—The individual membership of the Society at the present time is 3,256. We have lost 14 by death—S. E. Barnes, L. P. Breckenridge, C. J. Cosandey, E. P. Culver, S. G. George, C. D. Knight, H. W. Moore, A. E. Norton, R. E. Nyswander, Charles Puryear, U. J. Rappel, W. B. Russell, F. H. Sibley, Eric Therkelsen—82 by resignation, and 83 were dropped for non-payment of dues, a total loss of 179. The Membership Committee has added 246 new members to the rolls, making a net gain of 68. We have added 4 institutional members, making a total of 157—3,413 total. Among the 246 new members were 1 president, 8 deans or directors, 39 professors, 26 associate professors, 50 assistant professors, 107 instructors, 2 from high schools, 11 from industry, and 2 from the army or defense training. It would seem possible that the membership might remain stationary next year in view of the fact that many members are entering industry or military service.

Sections and Branches.—Vice-President Conrad will make a detailed report to you in regard to this activity of the Society. The Upper New York Section, which has been in the process of formation for a year or two, became active this year. The Texas Section was expanded to include Texas, Oklahoma and New Mexico and will now be called the Southwest Section.

Conferences.—Vice-President Moreland, with the assistance of the chairmen, arranged 22 conferences for this meeting. These conferences will be held all day Monday, and Tuesday and Wednesday afternoons.

Life Membership.—We have requests from three members for life membership which carries with it exemption from payment of dues. These requests are in order according to the Constitution. One is from a member 48 years of age, a member for 25 years; another is from a member 52 years of age, a member for 26 years; and the third is from a member 69 years of age, a member for 34 years.

I believe in view of the above and other suggestions received in this office that the Council should authorize a committee to study the present Constitution and By-Laws.

Divisions.—The Council, at its meeting last year, appointed a committee to consider the relations of divisions to the Society. This Committee will have a report to make to the Council this year.

The Division on Civil Engineering has requested permission of the Council to hold a conference on aircraft structures at New York University, September 5–6, 1941, without expense to the Society.

The Division on Engineering Drawing proposes

1. To undertake a national survey of engineering drawing, under the direction of its own Executive Committee and such other officers as the parent society may wish to appoint;

2. That funds for this purpose to the extent of approximately $250.00 be secured with the aid of the parent society.

Engineers' Council for Professional Development.—This Society continues its coöperation and support of ECPD. A contribution of $500.00 was again authorized by the Council last year for the support of the activities of the Committee on Engineering Schools. We published, in the JOURNAL OF ENGINEERING EDUCATION, a report to the boards of the constituent bodies by Chairman R. E. Doherty. The Society is represented on this body by R. A. Seaton, R. E. Doherty and C. C. Williams. The term of C. C. Williams expires this year.

Special Committees of the Society.—A Committee on Acceleration of the Regular Engineering Programs considered very carefully the desirability and the feasibility of accelerating the engineering programs. The Executive Committee of the Society authorized the expenditure of the expenses incident to a two-day meeting of the Committee in Pittsburgh. Considerable pressure had been exerted to accelerate the regular engineering programs. The report of your committee was submitted to the U. S. Commissioner of the Education through the Advisory Board of EDT. A consideration of the facts thus presented led the Commissioner to the decision that it would be unwise, at least in the present state of the defense program, to accelerate the regular engineering programs.

The Council last year authorized the appointment of a committee on Procedure and Method of Nomination and Election of Officers and Members of Council. After a period of extensive correspondence, it appeared to the Committee that a meeting should be held in order that various questions raised could be thoroughly discussed. The Executive Committee authorized the expenditure of funds for such a meeting in Pittsburgh. The report of this Committee was submitted to the Council for ballot. The results of that ballot were such that it was deemed advisable to have the chairman of the Committee, A. H. White, present the matter to the Council at one of its meetings at Michigan for further discussion.

One of the most important reports published during the past year was the report of the Committee on Research. This was pub-

lished in the March and April issues of the JOURNAL OF ENGINEERING EDUCATION.

Engineering Defense Training.—A year ago at our convention President Ferguson was in frequent telephone conversation with Dr. Kelly of the U. S. Office of Education in regard to the part that the engineering colleges should take in the defense program. Much water has gone over the dam since that time and it may be wise to summarize briefly the part that the engineering schools are taking in the defense program. Most of the items which I mention will be discussed in great detail in some part of our program. Of course, the defense program immediately led to many difficulties but I think most of them have been solved in a satisfactory manner.

1. The appropriation by Congress of $9,000,000 to the U. S. Office of Education for engineering defense training of college grade has been administered in a remarkably successful manner. Approximately 115,000 students have been enrolled in these courses. Not only have these courses contributed to the defense program but I believe they have contributed materially to the engineering colleges giving the courses in two obvious ways: (*a*) Permanent equipment has been increased about $1,000,000; (*b*) The income of the teaching staff has been increased by about 3 to 4 million dollars.

2. One of the most difficult problems was in connection with the Selective Service Act. As you are well aware all college students received deferments until July 1, 1941. All engineering students have now been deferred. Also, upon graduation, these men are now being deferred by the action of the firms that employ them.

3. Early in the academic year considerable difficulty was experienced by having the younger members of the teaching staffs called into active service through the Selective Service Act. Such men can now be deferred upon application of the institution.

4. A considerable number of members of faculties were reserve officers. It is a serious question as to whether an institution should ask to have them deferred from the call to active service. In some cases it is probably advisable and such deferment can be obtained now, although in general it would seem that if a man has become a reserve officer it means definitely he should enter active service when required.

5. A continuation and expansion of engineering defense training program is provided for in a bill now before Congress.

6. The engineering defense training program, which will hereafter be known as Engineering, Science and Management Training Program, interests a large number of members of this Society. It was deemed important to publish in the JOURNAL OF ENGINEERING EDUCATION as rapidly as possible all information available con-

cerning this program. Dean R. A. Seaton, Director of EDT, has been extremely kind in providing material for the JOURNAL. I believe the publication of this material has been beneficial to the engineering colleges. The U. S. Office of Education sends out to college presidents, deans and directors of EDT courses frequent statements in regard to the progress of the program, but it was felt that a wider dissemination of the information could be made through the JOURNAL OF ENGINEERING EDUCATION.

7. Those in charge of EDT are taking advantage of the attendance of the Regional Advisors at our Michigan meeting and have scheduled a conference of these men immediately following our meeting. This conference will begin Friday noon and run until Saturday evening, June 27–28, 1941.

NATIONAL COMMITTEE ON EDUCATION AND DEFENSE

Through your representatives on this Committee, sponsored jointly by the American Council on Education and the National Education Association, we have been able to coöperate very closely with all the developments in the fields of education with relation to the defense program. This Committee has been very effective in smoothing out a great many of the difficulties which might have caused much trouble.

REPORT OF THE TREASURER, W. O. WILEY

Dr. F. L. Bishop, Secretary
Society for the Promotion of
Engineering Education
University of Pittsburgh

Dear Dr. Bishop:

I have audited as of this date the accounts for the Society for the year ending June 30, 1941 and enclose the following statements:

1. Statement of Cash Account
2. Income and Expense Statement
3. Balance Sheet

These statements have been prepared from records and information furnished by your office. Cancelled checks have been examined and compared with supporting invoices. All receipts have been checked against bank deposits.

It is my belief that the attached statements show a true financial condition of the Society at this date.

Very truly yours,

H. E. DAN,
Auditor.

SOCIETY FOR THE PROMOTION OF ENGINEERING EDUCATION
STATEMENT OF CASH ACCOUNT
June 16, 1941

BALANCE ON HAND—June 5, 1940		
Forbes National Bank—Checking Account	$ 6,172.60	
Forbes National Bank—Savings Account	7,803.78	$13,976.38
RECEIPTS:		
Current Dues	$15,156.86	
Back Dues	1,485.00	
Dues in Advance	130.00	
Sales of Publications	557.88	
Advertising	2,203.51	
Sale of Emblems	65.00	
Interest on Savings Account	110.87	19,709.12
Total		$33,685.50

DISBURSEMENTS:		
Cost of Publications	$ 7,665.73	
Cost of *Proceedings*	336.99	
Honorarium for Secretary	2,000.00	
Clerical Assistance	4,000.00	
Travel and Entertainment—Secretary's Office	169.74	
Committee Expenses	244.68	
Expenses—Committee on Election Procedure	227.82	
Expenses—Committee for Acceleration of Engineering Program	745.42	
Contingent Fund for Officers	750.94	
Printing, Postage, Office Supplies, etc.	1,081.29	
Expenses—1940 Meeting	664.24	
Expenses—1941 Meeting	383.97	
Dues—American Council on Education	100.00	
Dues—American Engineering Council	125.00	
Contribution to Engineers' Council for Professional Development	500.00	
Advance for Lamme Medal	175.49	19,171.31
BALANCE ON HAND—June 16, 1941		
Forbes National Bank—Checking Account	$ 6,599.54	
Forbes National Bank—Savings Account	7,914.65	$14,514.19

SOCIETY FOR THE PROMOTION OF ENGINEERING EDUCATION
BALANCE SHEET

June 30, 1941

(Prepared June 16, 1941)

ASSETS

Cash:		
Current Fund	$ 6,599.54	
Petty Cash Fund	300.00	
Life Membership Fund	866.99	$ 7,766.53
Savings Account:		
Forbes National Bank—No. 3809		7,914.65
Benj. G. Lamme Trust Fund:		
Securities and Mortgages	$ 4,716.88	
Uninvested cash	399.25	
Gross Income with Trustee	105.63	
Checking Account	163.02	5,384.78
Prepaid Expenses—1941 Meeting		383.97
Inventory		1.00
Accounts Receivable:		
Advertising	$ 500.00	
Dues	900.00	
Lamme Award	175.49	1,575.49
Furniture and Equipment (est.)		100.00
		$23,126.42

Liabilities

Life Membership Fund		$ 866.99
Benj. G. Lamme Trust Fund		5,384.78
Prepaid Membership Dues		130.00
Accounts Payable—June JOURNAL		600.00
Surplus Account:		
Balance at June 30, 1940	$14,599.31	
Surplus for present year	1,545.34	16,144.65
		$23,126.42

Society for the Promotion of Engineering Education
Income and Expense Statement

For the Year ending June 30, 1941

(Prepared June 16, 1941)

Expense

Cost of Publications	$ 6,665.73
Cost of *Proceedings*	336.99
Expenses—1940 Meeting	1,738.67
Honorarium for Secretary	2,000.00
Clerical Assistance	4,000.00
Printing, Postage, Office Supplies, etc.	1,081.29
Travel and Entertainment—Secretary's Office	169.74
Committee Expenses	244.68
Expenses—Committee on Election Procedure	227.82
Expenses—Committee for Acceleration of Engineering Program	745.42
Contingent Fund for Officers	750.94
Dues—American Council on Education	100.00
Dues—American Engineering Council	125.00
Contribution to Engineers' Council for Professional Development	500.00
	$18,686.28
Surplus for the year	1,545.34
	$20,231.62

Income

Current Dues	$16,209.36
Back Dues	785.00
Sales of Publications	557.88
Advertising	2,503.51
Sales of Emblems	65.00
Interest on Savings Account	110.87
	$20,231.62

ENGINEERING DEFENSE TRAINING*

By ROY A. SEATON †

Our country is now engaged in a gigantic struggle for national defense against the most powerful armed forces the world has ever known. Democracy, freedom, and personal liberty are at stake. Efforts at appeasement of the aggressors have served but to delay preparedness and prevent united action by the peace-loving nations. One by one these nations have been crushed because they were individually helpless—unready and unwilling to fight until it was too late. The brutal and ruthless axis powers have robbed and enslaved the peoples of the conquered countries, and have used the resources of their victims for the enslavement of still other nations unable to defend themselves. Czechoslovakia, Poland, Denmark, Norway, Albania, Belgium, Holland, France, Jugoslavia, and Greece have fallen and been despoiled. Other countries have been bullied and bribed into non-resistance or active coöperation with the aggressors. Within the past few days Russia has been treacherously attacked, notwithstanding her mutual assistance pact, in order to rob her of her grain and oil. Our own country, at long last, is awakening to the necessity of arming itself with all possible speed and furnishing all possible aid to Britain and China to prevent the collapse of their resistance, followed by our own destruction. The great danger is that our defense efforts and the aid we can furnish will be too little or too late.

Modern warfare is now so highly mechanized, and mechanized warfare is so overpowering and deadly, that troops and nations not properly equipped for war are helpless against those that have an ample supply of suitable equipment. Nazi successes so far have been largely due to abundant supplies of the most modern equipment, together with great productive capacity, accumulated and developed through years of preparation for war; while other countries, like our own United States, were following peaceful pursuits without thought of armed conflict. Now we are faced with the problem of not only surpassing Germany's rate of production of munitions, but of so far exceeding it as to catch up quickly with

* Presented at the 49th Annual Meeting, S. P. E. E., University of Michigan, June 23–27, 1941.

† Dean of the Division of Engineering and Architecture, Kansas State College, absent on leave to serve as Director of Engineering Defense Training in the United States Office of Education.

her large volume of accumulated supplies. The urgent need for war equipment was forcefully presented last spring by Prime Minister Churchill in his plea for America to furnish Britain with the "tools" to carry on her fight for freedom, and more recently by President Roosevelt in his promise to make America "the arsenal of democracy."

For centuries engineers have rendered important services in warfare. These have been of constantly increasing value through the years as mechanization of armed forces has increased. In 1918 5 men were required to produce supplies for each soldier at the front, but today warfare is so completely mechanized that 18 men at home are required to maintain 1 soldier on the firing line. The technical branches of the armed forces manned by engineers now are so important and extensive, and the munitions of war produced under the direction of engineers now are so essential, are of such varied and complex character, and are needed in such enormous quantities, that present-day warfare, both in attack and in defense, may fairly be said to be an engineering enterprise.

Not only must guns, tanks, explosives, ammunition, airplanes, and naval vessels be made, but new factories must be built and equipped; additional machine tools must be manufactured; increased supplies of raw materials must be produced and suitable substitutes discovered and utilized; additional sources of power must be developed; communication and transportation systems must be expanded; cantonments, fortifications, and air and naval bases must be constructed; and a host of other technical activities must be carried on.

In all of these activities engineers are key men, necessary in large numbers for efficient planning, production, operation, and management. Engineers must make the designs, prepare detailed drawings, supervise construction and production, inspect and test raw materials and completed items, and carry on research and development activities for new and better products, improved methods of production, and suitable substitute materials.

The number of engineers available in normal times was barely sufficient to meet the needs of peace-time industry. Great numbers of additional engineers are now needed, both to handle our increased defense production and to serve in technical capacities in the armed forces. We are only getting started, both in our mobilization and in our defense production; yet already the shortage of engineers has become acute. Sidney Hillman, Associate Director of Production Management, stated on April 21, 1941: "From studies which I have asked the Bureau of Labor Statistics to make, I conclude that the supply of manpower in the specialized professional fields listed below, which have a definite and direct relationship to the

national defense program, is at a dangerously low level. It is necessary that this level be raised by every means within our power." The occupations listed in this group are Chemistry, Civil Engineering, Electrical Engineering, Chemical Engineering, Mining and Metallurgical Engineering, and Mechanical Engineering.

Mr. Hillman stated further: "The following are professional occupations in which authorities allege that a shortage will exist, but which have not yet been studied by the Bureau. However, there is complete agreement among representatives of industry, of American colleges and universities, and of the practicing professional groups that the present and future demands of the national defense program for college-trained scientific personnel will transcend the normal supply of graduating students that comes onto the labor market at the close of the academic year." The occupations listed in this group include Agricultural Engineering, Sanitary Engineering, Physics, and Geology in the subdivisions of Geo-Physics, Meteorology, Hydrology, and Cartography, as well as several other scientific and professional occupations not closely related to engineering.

It is extremely difficult to determine, even approximately, the extent of the shortage of engineers which now exists, and impossible to secure firm figures on future needs. Certain industries have been carefully studied upon the basis of present and anticipated production requirements, but the picture constantly changes as our defense program develops, and figures become obsolete even before they can be compiled.

The Bureau of Labor Statistics of the United States Department of Labor stated as of March 31, 1941: "The present schedule of ship completion dates and the pressure of the ship repair program will require a continued increase in the number of workers to be hired until the peak employment is reached in September 1942, when a total of more than 560,000 shipyard workers will be required by the industry. In other words, employment between February 1941 and September 1942 will have to more than double to execute the present schedule of operations. . . . Approximately 48 per cent of the 309,000 workers to be added by September 1942 will be skilled workers, 24 per cent will be semi-skilled, 23 per cent unskilled, and the remainder (5 per cent, or 15,500 workers) supervisory employees."

The Ordnance Department of the Army has recently estimated that it will need from July 1, 1941 to June 30, 1942, about 10,000 additional civilian professional personnel in critical positions, chiefly as inspectors of materials, ammunition, and explosives, chemical engineers and chemists, mechanical engineers and draftsmen.

It also estimated that from 30,000 to 40,000 additional inspectors will be needed by manufacturers in the production of ordnance materiel for the Army. Since this estimate was prepared, an additional request for 10 billion dollars for the War Department has been submitted to Congress.

The airplane industry has expanded, and must continue to expand its production enormously. In the New York City area last October it was found that since 1937 the number of workers in this industry had multiplied 50 times, and it was estimated by responsible executives that within a year the number of workers might well be "more than three times as great as today." During the same period the number of airplane workers in Los Angeles County, California, increased from 7,400 to 55,000, and it was estimated by airplane company officials that 150,000 might be employed by the beginning of 1942. Similar expansions have occurred and are expected for the near future in many other places, and numerous completely new and very large centers of airplane manufacture have been established. It is estimated that about 10 per cent of the airplane workers occupy supervisory and technical positions for which some engineering training is necessary or desirable.

An official of the Labor Division of the Office of Production Management stated on June 4, 1941, that 1,300,000 additional men and women must be employed in major defense industries before the end of 1941. He listed 285,000 needed in ship production, 250,000 in the production of tanks and guns, 100,000 in the production of munitions, and 400,000 in the production of airplanes. If 5 to 10 per cent of these workers are to occupy supervisory and technical positions requiring engineering training, from 65,000 to 130,000 additional technically trained men and women will be needed in the defense industries of this country in the next six months. In addition large numbers must be upgraded for increased responsibilities.

Our defense program now provides for the expenditure of about 50 billion dollars, and future large expansions of the program appear to be inevitable. Only $15,641,000,000, or less than one-third of the total for the present program, had been contracted for by May 17, 1941, and relatively little of the contracted work had been completed. It is evident that only a very small part of the full effect of the defense program has yet been felt by industry. Peak production certainly cannot be reached before the latter part of 1942, and it may not come until much later.

Engineering colleges of this country will graduate this year only about 12,000 men, of whom perhaps one-third to one-half will

enter the armed forces, leaving for civilian industries only about half or two-thirds the number which would be required to meet their normal needs if we had no defense program and if industry had not itself been drained of its technically trained personnel by the calling of reserve officers into the armed forces. Significant additions to the normal number of engineering graduates cannot be produced for several years, but the defense need is immediate. Production of defense materiel cannot wait. If the industries cannot get men and women with the proper training for their necessary technical and supervisory positions, they must use such personnel in these positions as they can get. It is to meet this situation that the Engineering Defense Training program has been organized.

In recognition of the large existing and impending shortage of engineers, Congress, last fall, appropriated $9,000,000 "For the cost of short engineering courses of college grade, provided by engineering schools or by universities of which the engineering school is a part, pursuant to plans submitted by them and approved by the Commissioner, which plans shall be for courses designed to meet the shortage of engineers with specialized training in fields essential to the national defense. . . ."

It should be noted carefully that the Engineering Defense Training program is intended to be a program of the engineering schools, not of the United States Office of Education or of the Federal Government. The Act under which the program is organized specifically states that the appropriation is "For the cost of . . . courses . . . provided by the engineering schools . . . pursuant to plans submitted by them. . . ." It is a truly democratic program with the initiative and control resting chiefly in the engineering schools themselves. The function of the United States Office of Education in the program is only to make it possible for the engineering schools to carry out the plans which they themselves propose for meeting the shortage of engineers, and to exercise such administrative supervision and to effect such coördination as may be necessary to insure that the funds provided by the Federal Government shall be properly and wisely expended for the purpose for which they were appropriated.

It is obviously impossible for the engineering schools to condense into a short course education and training equivalent to that given in their four-year curriculums. Neither the U. S. Office of Education nor the engineering schools have any illusions that fully trained engineers can be produced in a period of a few months. It is possible, however, for the engineering schools to give, in a period of a few months, training which will make men and women more useful in defense work than they would be without this training.

Engineers who are fully qualified and experienced in certain types of work can, in a short time, be given useful training for new and unfamiliar defense tasks. Civil Engineering graduates, for example, can thus be trained for airplane design. Partly trained engineers can be given additional training to fit them for more responsible work. Each year, for financial or other reasons, many students drop out of the engineering schools after one, two, or three years of college work. Additional intensive, specialized courses will make them more useful in defense industries. Men and women who have had no engineering training, but who have a good general or scientific education, can be trained in certain techniques to enable them to perform repetitive or semi-routine tasks usually performed by engineers. Even high school graduates, with or without industrial experience, can be given training that will enable them to function as assistants to engineers, draftsmen, or minor inspectors or supervisors. All of these types of training are comprised in the Engineering Defense Training program.

Promptly after the appropriation Act was signed by President Roosevelt on October 9, 1940, the organization for handling the program was set up by the United States Office of Education. A national advisory committee, composed of leading executives of engineering schools and practicing engineers, had already been appointed. A small central administrative staff of experienced engineering educators was assembled in Washington. Prominent engineering-school executives were appointed as regional advisers in 22 areas comprising the entire United States. Representatives of engineering schools within each area were organized into regional committees, of which the regional advisers are chairmen. Needs of industries for Engineering Defense Training were surveyed by these committees and courses in the engineering schools were planned to meet these needs. Proposals for these courses were prepared by the engineering schools and submitted to the U. S. Office of Education. By December 3, 1940, less than two months after the appropriation Act was signed, the Washington office had received 358 proposals for Engineering Defense Training courses from 72 engineering schools providing for a maximum enrollment of 26,000 students. The first approvals of these proposals were issued on December 5, and actual instruction in a few courses was started almost immediately. From that time the program grew rapidly and steadily. By December 20, 418 proposals from 84 institutions for a maximum of 28,928 students had been approved, and instruction in many courses began early in January, 1941. By March 29 the totals had risen to 1,093 approved proposals for Engineering Defense Training courses in 133 schools for a maxi-

mum of 77,562 students, after deducting courses cancelled for lack of students and excess of maximum authorized enrollments over actual total enrollments reported to that time. The totals, less such deductions, have now reached about 2,300 approved proposals from 144 schools for a maximum of over 125,000 students. Total encumbrances against the $9,000,000 appropriation exceed $8,500,000, of which sum approximately one-half has actually been sent to the engineering schools, while the remainder is encumbered for courses for which payments are yet to be made.

Some further reductions in these figures will no doubt occur as actual enrollment data become available for courses started recently. It appears evident, however, that the total net enrollment in the Engineering Defense Training program for the present fiscal year will be substantially in excess of 100,000 students. The total, regular and special, day and evening, engineering enrollment of 155 schools in the United States, as reported in the December, 1940, number of THE JOURNAL OF ENGINEERING EDUCATION, was about 110,000 students. Thus, in a period of a few months, the engineering schools have enrolled in Engineering Defense Training courses a number of students nearly or fully equal to their normal total enrollment of engineering students.

Breakdowns of the Engineering Defense Training enrollment as of May 13, 1941, by course classifications and by states and engineering schools, were published in the June number of THE JOURNAL OF ENGINEERING EDUCATION. Hence, while the total number of enrollments is now considerably greater and several additional schools are now coöperating in the program, such breakdowns will not be included in this report. It may be said, however, that the later courses include a substantially greater percentage of trainees in courses in the fundamentals of engineering, designed for recent high school graduates.

Two general types of courses are given in the Engineering Defense Training program. The first consists of intensive full-time or pre-employment courses given on the campus of the engineering school and designed to fit trainees, not already employed, for work in the defense industries or in the defense agencies of the Government. Only about 10 per cent of the trainees are enrolled in such courses. The remainder are in courses of the second type—part-time, in-service courses, for persons already employed. While many of these trainees are not now employed in defense industries, but are fitting themselves for such employment while they continue to earn a living at other work, most of them are already so employed. By taking Engineering Defense Training courses they are fitting themselves to do their present jobs better, or to accept greater responsibilities. This upgrading of the present personnel

of defense industries and governmental agencies is a very important part of our work. Many reports of promotions of trainees in the part-time courses have already reached us. Reports indicate also that no difficulty is being experienced in placing trainees of the full-time courses.

The reception given the Engineering Defense Training program by engineering schools, by industries, and by governmental agencies has been extremely gratifying. Almost without exception the reports we have received from officials of the coöperating schools are enthusiastic about the quality of the work done by the trainees and the valuable results that are being obtained from the courses. A few typical extracts from hundreds of letters received from engineering-school officials will serve to illustrate this fact.

"We have had more demands for these men than we can possibly fill, and indications are that the demand will increase as the summer months pass."

"The present part of the E.D.T. program . . . has been far more successful than I anticipated."

"When this program began, we had to point out the possible need to industrial executives. Now they are pointing out the need to us."

"It has been amazing to see the extent to which industrial leaders have been willing to go to secure advanced training for their men. For example, the aircraft industry has arranged the duties of important technical men at all levels to permit them to serve as instructors. This includes chief designers, research engineers, and others of similar rank."

"Everyone is amazed and pleased with the caliber of the students and their enthusiasm."

"The program has satisfied a need and has made a contribution far exceeding anything envisaged six months ago."

"There is an enthusiasm among the instructors and trainees that is very gratifying. They are all working hard, attendance is better than we anticipated and we are confident that the results will more than meet our expectations."

"The courses are progressing smoothly and with surprisingly good attendance. The character of the students, their aptitude and earnestness, has been an inspiration to the faculty in charge and has in some cases changed an attitude of skepticism into one of enthusiasm."

Industrial executives and plant officials of defense industries are equally enthusiastic as the following typical quotations from other hundreds of letters clearly indicate.

From The Glenn L. Martin Co. of Baltimore, Maryland: "The enormous expansion of the aircraft industry has brought about an

acute shortage of trained personnel, particularly in engineering, tool design and inspection. . . . The Defense Training Program fills a very acute need and the large attendance in these defense training courses is a good indication of the importance of this work.

"Approximately 450 of our employees are studying and learning in these defense training courses and we believe that this training should permit these men to assume, gradually, more responsibility due to their increased knowledge and special training gained from this training program. Consequently, it will permit the upgrading of many men in various departments to fill positions of greater responsibility."

The Engineering Defense Training program for employees of this company has been greatly expanded since this letter was written.

From an official of the Lockheed Aircraft Corporation of Burbank, California: "This program has filled a need which we have long felt but about which we were able to do little."

Similar letters have been received from most of the important aircraft manufacturing companies.

From the president of the Sun Shipbuilding and Dry Dock Co.: "The Engineering Defense Training program . . . is proving to be a very helpful aid to us in our increased defense program."

From an official of the Carnegie-Illinois Steel Corporation: "There can be no question of the value of the E.D.T. program both to industry and the community."

From the president of the Manufacturers' Association of Connecticut: "We are very pleased to add our strong endorsement in evaluating the present Engineering Defense Training program. This program is an important contribution in meeting the needs of Connecticut industry for an ever increasing number of skilled and semi-skilled or trained and semi-trained men in the engineering and mechanical fields."

From the director of training of Pratt and Whitney Aircraft: "The training programs we have jointly instituted and carried out have been of great value to our organization. . . . The results of this training are clearly evident not only by the improved skill of the men but their attitude and conduct insofar as their job is concerned."

From the president of the Safety Engineers Club of Philadelphia: "Frankly, I anticipated that a minimum of good would be derived from such courses, but I am more than pleased to say that in my opinion the job that is being done is a credit to everyone connected with it.

"I have found active participation and awakened interest on the part of men who showed no such interest before, and they are

now absorbing these courses which will be of inestimable value in safety work.

"I want to wish you further success and hope that these courses may continue and be amplified as the years go on."

At the start of the Engineering Defense Training program Navy officials were doubtful whether any naval officers would be trained under this program. Later they asked that training in Diesel Engineering be given to 5 officers. Before this training was started, the number of officers assigned to take it increased to about 50, and the total number has since risen to more than 200. Now it is expected that about 1,800 naval officers will take Diesel Engineering courses in the Engineering Defense Training program next year. Courses in Naval Architecture, Aeronautical Engineering, and other subjects are also being given to many naval officers. Numerous courses are also being taken by commissioned officers of the Army as well as by enlisted and civilian Army personnel.

The following extracts from recent letters from the Secretaries of the War and Navy Departments to the Federal Security Administrator are of special interest.

From Secretary Stimson: "During the past few months the commanding officers of over 50 posts and stations have requested and received assistance from state and local schools participating in the Vocational and Engineering Defense Training programs under the supervision of the United States Commissioner of Education, in the qualification of military personnel to fit them for military duties essential to their organizations. The Army has found this aid very beneficial."

From Secretary Knox: "The Navy Department has taken advantage of the facilities offered by the U. S. Office of Education, Federal Security Agency, to obtain engineering and vocational training for a considerable number of officers and enlisted men of the U. S. Navy. These programs under the supervision of the United States Commissioner of Education have been of great assistance in preparing naval personnel for more efficient service, especially in such subjects as diesel operation and aircraft maintenance where the expansion program calls for a large increase in specialists."

A bill providing $17,500,000 for continuing Engineering Defense Training through the fiscal year ending June 30, 1942, and giving similar training in the closely related fields of chemistry, physics, and non-engineering types of production supervision is now before Congress. Of the total amount provided by the new bill it is expected that $16,400,000 will be for the training of engineers, $500,000 for chemists, $100,000 for physicists, and $500,000 for production supervisors outside the field of engineering. The

bill which carries this appropriation item has already passed both houses of Congress, but awaits reconciliation of minor differences in other items not related to our program. Its final passage and signature are expected within the next few days. The essential features of the bill which relate to college-level defense training courses, except those mentioned above, follow closely the provisions of the Act under which the Engineering Defense Training has been operating this year. It is expected that the administration of the entire program will be handled by the same staff and organization that are handling the program this year, with the addition of some specialists in the new fields to the central staff, the national advisory committee, and regional and institutional committees.

The administration of the Engineering Defense Training program in the central office has been a strenuous but a very interesting task. One of its most pleasant features has been the close association it has brought with engineering educators throughout the country. The advisory committee members, regional advisers, institutional representatives, engineering school administrators and faculty members, and others concerned with the program have given wonderful coöperation. Special mention should be made of the very valuable services that have been rendered by Allen W. Horton, Jr., Assistant Director; by Dean George W. Case of the central staff, who has been in charge of the arduous work of analyzing proposals and making recommendations for their approval, modification, or rejection; and by Dean A. A. Potter, Consultant to the Office of Education and Chairman of the National Advisory Committee, who laid the foundations for the program last summer and fall, and has since rendered invaluable advice and assistance in its organization and administration. Dr. J. W. Studebaker, Commissioner of Education, and Dr. Fred J. Kelly, Chief of the Division of Higher Education, have been most helpful in our efforts to simplify procedures and eliminate unnecessary red tape.

In my opinion, engineering educators and the engineering schools have done a magnificent job of developing such an enormous program in such a short time and operating it so successfully. This record has been achieved only through long hours of strenuous labor by many persons, often at great personal inconvenience and sacrifice. It is most gratifying that persons, groups, and institutions have been willing to subordinate individual desires, interests, and ambitions to the greater issue of the common good, and thus make possible such an important contribution to national defense.

We are now only well started on our task, however. Much more remains to be done than we have yet accomplished. In spite of all our efforts and achievements, shortages of supervisory and technical

personnel needed for defense are now much greater than when the program was begun. We must redouble our efforts, and meet all the needs for defense training at the college level up to the limits of the capacities of our institutions and of the funds that may be made available. In the light of what has already been accomplished, I am confident that we shall succeed in this most important undertaking for the defense of our country, democracy, and freedom. Let us make sure that the contribution of our engineering schools to national defense will not be too little or too late.

By A. A. POTTER *

In the spring of 1940 it became apparent that the National Defense Program required for its effectiveness large numbers of skilled mechanics as well as many engineers competent in a wide variety of technical services. It was felt that the trade schools and engineering colleges, which represent a large investment, should be utilized in meeting the shortage of skilled workers and engineers.

On May 29, 1941, the U. S. Commissioner of Education presented, at the request of the President of the United States, a report on "Training for National Defense," utilizing the existing trade school facilities and those of the engineering colleges. During the first World War the engineering colleges of this country were responsible for the major portion of the vocational training program of the U. S. Army. The Vocational Division of the Students' Army Training Corps was mainly concerned with the training of mechanics and practically no attention was given to defense training on the engineering college level. During the past twenty-four years our government has coöperated with the various states in the development of a nation-wide program of vocational education. As a result there are at present in this country over 1,000 public vocational and trade schools with a plant valued at more than one billion dollars. In the May 29, 1940, report of the Commissioner the proposed training program in schools and colleges called for an expenditure of $63,000,000 for the use of existing public trade school facilities, $50,000,000 for the expansion of trade school facilities requiring capital investment and $14,000,000 for defense training through engineering colleges.

On June 13, 1940, a group of presidents and deans of engineering schools met in Washington, at the call of the U. S. Commissioner of Education, to discuss the various types of educational service

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the engineering schools can provide in the national defense training program. At this meeting it was emphasized that emergency defense training should be an additional activity of the engineering schools which should not interfere with the regular collegiate programs.

On June 22, 1940, Congress passed a law appropriating $15,000,000 for a summer defense training program of "less than college grade." The term "less than college grade" refers to the character and content of courses and not to the institution giving the training. Such a program ordinarily involves courses for which high school graduation is not a prerequisite and which do not conform to college standards. Teachers of "less than college grade" institutions are selected for craft competency and not for academic preparations. A number of the engineering colleges offered to cooperate in the vocational types of training of "less than college grade." There was, however, a general feeling among engineering educators that the engineering schools should utilize their facilities, without interrupting their regular programs leading to degrees, mainly for specialized training on the engineering school level.

Early in July a request came from Washington to aid the U. S. Office of Education in presenting "a proposal for the consideration of the Defense Council and the Congress concerning just what the colleges of engineering can do to contribute most effectively to the defense training program, and to be the liaison officer between the engineering schools and the government agencies concerned with national defense."

In order to appraise the needs for defense training on the engineering school level, contacts were made with the National Defense Council, the U. S. Army, the U. S. Navy, the Civil Service Commission, the Department of Labor, the National Academy of Science, the Maritime Commission, and the U. S. Weather Bureau, as well as representatives of industries concerned with national defense. While much uncertainty was found about the over-all effort during the next two years, there was evidence of a marked shortage in naval architects, ship draftsmen, marine engineers, engineers skilled in airplane structures and airplane power plants, machine tool designers, meteorologists, inspectors of materials, and particularly engineering supervisors to speed up production in the industries essential to national defense. Representatives of the Army, Navy, Defense Council, Civil Service Commission and other government departments were convinced that to an extraordinary degree our defense program is dependent upon technical and supervisory engineering talent, and offered the fullest coöperation to the engineering colleges, as they realized that neither industry nor

the armed forces of our government have the facilities for training engineers and engineering supervisors. Those interviewed advised that:

1. Engineering colleges should be encouraged to maintain their staffs intact and to continue their present undergraduate and graduate programs of study leading to degrees.

2. Engineering colleges which have *special facilities* should be advised to plan short intensive programs on the "college level" for the benefit of the Army, Navy, and industry. Special consideration should be given to in-service training as well as to the needs of the community in which the engineering college is located.

3. In certain sections of the country, due to the absence of trade schools, engineering colleges may well offer vocational programs of "less than college grade." In general, however, it was felt that training of less than college grade should be carried on largely by public vocational and trade schools.

A study was made of the facilities available, in staff and equipment, at the engineering colleges for specialized training on the engineering school level as well as on the less than college grade level. The results of these studies were incorporated in confidential briefs which listed the facilities available for thirty-one intensive training programs on the "engineering school level" as well as for vocational courses of less than college grade. Special confidential briefs were also prepared at the request of the U. S. Army and Navy regarding outstanding facilities for training in certain engineering fields of special interest to the armed forces of our country.

On July 25, 1940, a draft of a bill was prepared which called for an appropriation of $14,000,000 for defense training on the engineering school level. This figure was based upon an estimated average cost of about $80 per student per month for a full time intensive course which involved about 20 classroom periods and about an equal number of hours per week of laboratory or design practice. The proposal was given consideration by the Bureau of the Budget at a hearing on August 9, 1940, and by the Appropriations Committee of Congress on August 30, 1940.

While waiting for action by Congress outlines of programs covering the most urgent needs were prepared after conferences with the U. S. Civil Service Commission and the governmental agencies affected. Each outline covered the purpose of the course, qualifications for admission, and outline of instruction with suggestion as to approximate time to be devoted to lectures, design, laboratory and preparation.

When it became apparent that Congress would give favorable consideration to Federal aid for defense training on the engineer-

ing college level, the Commissioner of Education invited on August 27, 1940, eleven representatives of the engineering and of the engineering teaching profession to act as an Advisory Committee on Engineering Defense Training. This Advisory Committee was intended to aid the Commissioner of Education in formulating policies, in facilitating coöperation of the engineering colleges of the country and the government, and in safeguarding the permanent defense values of engineering colleges. Thus from the very beginning plans were laid so that the training program was that of the engineering schools and not of the Federal Government. As the Director of the program (Dean Seaton) has indicated in his talk of yesterday the Engineering Defense Training Program was planned so that "the initiative and control rested chiefly in the engineering schools, the U. S. Office of Education making it possible for the engineering schools to carry out the plans which they themselves propose for meeting the shortage of technological talent. The only administrative supervision exercised by the U. S. O. E. is that necessary to insure that funds provided by the Federal Government are properly expended for the purpose intended when the appropriation was made by Congress."

The first meeting of the Advisory Committee on Engineering Defense Training was held in Washington on September 20 and 21, 1940. In addition to the members of the Advisory Committee there were present during all or part of the meetings representatives of the Advisory Commission on National Defense, Civil Service Commission, Army, Navy, and major staff members of the U. S. Office of Education. The following matters received consideration:

Safeguarding engineering colleges in the interest of national defense, defense training on the engineering college level, coördination of engineering defense training programs with defense training of less than college grade, with defense training within industry and with the special requirements of government defense agencies. Plans for the organization of the defense training program were laid at this meeting. It was agreed that full responsibility for the selection and admission of students to the defense training programs should be vested in the engineering colleges, but that high school graduation should be considered the minimum prerequisite. It was also agreed that the government should reimburse colleges for all costs and that no tuition be charged. The central office was charged with the responsibility of preparing course outlines and of continuing contacts with industry and government agencies with respect to needs. A field organization was suggested as well as a competent auditing staff. The Advisory Committee approved preparation by the Washington staff of "Answers to Questions

Pertaining to Engineering Defense Training" and different forms to be used in considering proposals from institutions. At this meeting the Advisory Committee proposed sample regional surveys to determine training needs in New York, Pennsylvania, California, and Chicago Metropolitan areas.

The sample regional surveys uncovered serious shortages in a number of industries. Thus it was found that the aircraft industry of Long Island and northeastern New Jersey area alone needed nearly one-half of the output of the engineering colleges of the entire country. In Pittsburgh, Pennsylvania, and the eleven surrounding counties only 257 men were qualified to meet a potential demand of about ten times that number. Definite shortages of technologically trained people were also found to exist in California and in the Chicago areas.

On October 9, 1940, Congress passed an act appropriating $9,000,000 to the U. S. Office of Education for "the cost of short engineering courses of college grade, provided by engineering schools or by universities of which the engineering school is a part . . . which plans shall be for courses designed to meet the shortage of engineers with specialized training in fields essential to the national defense."

The passage of this Act of Congress brought about a new relationship between the Federal Government and engineering education, all previous relations having been limited to land-grant colleges and universities. This legislation is also distinctive in that the Federal Government deals with individual engineering colleges rather than through a state board of vocational education which is the practice in the case of vocational education.

Immediately after the passage of the bill a regional organization of twenty-two advisers was set up to coördinate the engineering defense training program with the needs of industry and government. Those invited to serve as advisers, representing leaders in engineering education, have accepted this assignment which involves no compensation other than the opportunity to aid in national defense.

The first meeting of the regional advisers was held in Washington on October 31 and November 1, 1940. No detailed outline of the duties of regional advisers was necessary. Those in attendance felt that the adviser can aid most effectively by keeping in close touch with the defense industries and engineering colleges of his region and by thinking of the engineering defense program in terms of all of the engineering colleges of his region. He acts as chairman of a committee of engineering college representatives in his region responsible for the engineering defense training programs of their institutions and keeps the members of his committee fully

informed of actions taken at meetings of regional advisers. While the U. S. Commissioner of Education must maintain official contacts with educational institutions, the regional adviser provides informal and more personal relationship. The regional committee is expected to work out a systematic plan for contacting local industries and governmental groups concerned with engineering defense training, to assure their fullest coöperation in determining training needs, as well as in recruiting and placement. Major consideration was given at the first meeting of the regional advisers to the machinery of operation of the program, to the study of the "Answers to Questions Pertaining to Engineering Defense Training" prepared by the staff at Washington and to the reports of the sample regional surveys made to determine training needs in the four sections of the country. This meeting also afforded the regional advisers an opportunity to meet and to hear from representatives of the Army, Navy, Civil Service Commission, Bureau of Labor Statistics, Bureau of Employment Security, and of the National Defense Advisory Commission.

As the program was getting under way it became evident that the Washington office must have a more adequate staff to handle the engineering defense training program. This program is under the Chief of the Division of Higher Education of the U. S. Office of Education, but it was felt that a full-time director should be appointed with specialists to handle details pertaining to proposals, auditing, correspondence, publicity and regional matters. A director of the program was appointed during the latter part of November and other staff members have been added as quickly as suitable people could be secured. Nearly all of the major staff members are on leaves of absence from educational institutions or industry. Overhead costs less than 1 per cent.

The second meeting of the Advisory Committee on Engineering Defense Training was held in Washington on December 1 and 2, 1940, at which time the responsibilities of the Advisory Committee, the regional advisers, and the Washington office were discussed. Major consideration was given to general policies with reference to proposals and the Committee agreed that criteria to be borne in mind in evaluating proposals should be: Need for proposed training, special facilities available at engineering colleges in staff and equipment, geographical location of the college with respect to need, availability of students and cost. 358 proposals submitted at this meeting by 72 institutions were reviewed, and general policies were promulgated to be followed by headquarters staff in connection with the approval of other proposals submitted by colleges.

Meetings of the regional advisers were also held at Chicago on December 21, 1940, at Washington on February 7 and 8, 1941, and March 28 and 29, 1941, and a meeting was scheduled at Ann Arbor, Michigan, for June 27 and 28, 1941. The Advisory Committee had joint meetings with the regional advisers on February 8, 1941, and a separate meeting on March 8, 1941. These meetings have been helpful in clarifying operating details, in simplifying procedures and in bringing about effective coöperative relations between the engineering colleges and the U. S. Office of Education. These conferences of the advisers have been particularly valuable to the Office of Education in working out forms for the plan, proposals and procedure for obtaining and handling Federal funds. The U. S. Commissioner of Education was successful in securing approval for payments to institutions of estimates submitted in the final proposal on enrollment figures at the end of the second week of the training period as well as liberal interpretations of organization expenses, equipment and space charges, cancellation clause and other matters which are a protection to the engineering colleges coöperating in the training program.

At different times since last July suggestions have been made that the U. S. Office of Education aid in financing an accelerated regular engineering program. At the joint meeting of the regional advisers and the Advisory Committee on Engineering Defense Training on February 8 and 9, 1941, the Society for the Promotion of Engineering Education was requested to report on the practicability of accelerating graduation of engineering students. The special committee of the S. P. E. E. on Acceleration of the Regular Engineering Programs made its report at the March 8, 1941, meeting of the Advisory Committee on Engineering Defense Training recommending acceleration of graduation only for the class of 1942, providing the content of the engineering curricula is not materially changed or reduced, if the extra cost to institutions is met by a Federal grant, and students in the accelerated program are granted draft deferment until graduation. In its report the special S. P. E. E. committee also pointed out that this accelerated plan may lower the effectiveness of the educational process, will limit the availability of staff for Engineering Defense Training, and will interfere with the valuable research and industrial contacts of the engineering staffs. To assist in giving consideration to the proposed accelerated program the Chairman of the Advisory Committee on Engineering Defense Training consulted the Office of Production Management, the Army, the Navy, the Civil Service Commission, and the National Headquarters of the Selective Service. Those consulted, with the exception of the Civil Service Commis-

sion, advised against dislocating the programs of engineering schools by carrying out at this time any accelerated program even if no additional cost is involved. Neither West Point nor the Coast Guard Academy found it necessary to accelerate their programs. It was also felt that the cost estimate to the government of $500 per student for a probable saving of three months could not be justified to Congress in view of the other urgent defense needs. It was also found that the National Headquarters of the Selective Service is legally unable to make special recommendations with reference to the group of engineering students which may be affected by the accelerated program, as Congress was very specific and clear in its "prohibition against group deferments." Lack of official support to this program and the fact that the Selective Service System is legally unable to defer groups of students make acceleration of graduation from engineering curricula undesirable at this time.

The fifth meeting of the Advisory Committee was held in Washington on Friday, May 16, 1941. The Committee reviewed the accomplishments up to date and the proposed legislation for an expanded program on the college level after July 1, 1941. It was felt by the Committee that if Congress approves an expanded program to include chemistry, physics and management, the chemists, physicists and collegiate schools of business should be represented on the Advisory Committee. While in-service training is of major importance and should be expanded, more preëmployment courses are needed to meet the growing need for additional technological personnel in defense industries and government. The Advisory Committee favored greater attention to the training of instructors for the E.D.T. programs, particularly in view of the large number of in-service courses which have to be handled by people drawn from industry who are without teaching experience.

Since the first proposals were recommended by the Advisory Committee for approval on December 2, 1940, the program has grown so that by June 21, 1941, 144 engineering colleges were cooperating in giving specialized engineering instruction to about 100,000 people.

Regional differences in defense training needs and in facilities for instruction result in wide variations of the courses offered. Some are designed to increase the number of people on the subprofessional level, others to provide specialized information in a particular specialty, others to prepare people for a new field of activity, and still others to fit those employed in defense work for more difficult and responsible positions. About ninety per cent of those now enrolled in the engineering defense training program are in-service courses for those now employed. This is a most desirable

condition, and the up-grading process for the more important posts opens opportunities for the less trained people. While all of the instruction is expected to be of college grade, practically none of the courses carry college credit. The engineering defense training program is not a substitute for a regular curriculum leading to a degree but is intended only to meet the needs of national defense by providing intensive specialized training for partly trained engineers, by training for defense tasks engineers skilled in less essential specialties and by giving specialized instruction to people without technical education, so as to prepare them as assistants to engineers. In addition to this, the engineering defense training program is giving specialized instruction in aeronautics, Diesel engines and in other fields to those who now hold commissions or are preparing for commissions as engineering officers of the Army and Navy and in other branches as requested by the armed forces of our country.

To meet the needs for sub-professional trainees to act as assistants to engineers a Defense Training Institute was organized through the coöperation of eight engineering colleges in the metropolitan area of New York. Effective coöperative relations between engineering schools are also found in other areas. In some cases two or more institutions offer one course coöperatively, each school utilizing its available facilities most effectively. Special schools for the training of teachers of the "chemistry of explosives" were set up in order to make certain that instruction in this field will meet the requirements of the armed forces.

Full responsibility for the selection and admission of prospective trainees into the defense program is vested in the engineering colleges but without restriction as to age, sex, race, color, or condition of employment. To be admitted, however, students must meet the educational prerequisites set by the engineering colleges for the different courses and must be employable in defense work. While no guarantee can be given regarding placement, it is expected that the facilities of college placement bureaus, the U. S. Employment Service acting through 1,500 local state employment offices, and the U. S. Civil Service Commission will be utilized in placing trainees.

Statistics on disbursements of funds show the following trends: Cost of administration at institutions varies from 3 per cent to 39 per cent, the average being about 24 per cent of the total funds allotted. Instruction costs vary in institutions from 52 per cent to 92 per cent of the total cost, the average being about 67 per cent. For plant operation and maintenance the average is about 9 per cent and for equipment and leasing of space about 16.1 per cent of the funds allotted.

In April, 1941, a bill was prepared for the continuation of the program during the fiscal year ending June 30, 1942. Following a hearing before the Bureau of the Budget on May 3, 1941, the amount recommended by the President to Congress on May 13, 1941, was fixed at $17,500,000 "for courses designed to meet the shortage of engineers, chemists, physicists and production supervisors." Of this amount $16,400,000 were to be utilized in the continuation of the present engineering defense program, $500,000 for the training of chemists, $100,000 for the training of physicists and $500,000 for the training of production supervisors.

Hearings before the Congressional committees were held on Saturday, May 17, and Monday, May 19, and Tuesday, June 10, 1941.

On Monday, May 19, 1941, a conference was held with representatives from the American Association of Collegiate Schools of Business and with other leaders in business training. There appears to be in certain states an area in the defense training of production supervisors that cannot be fully served by the present E.D.T. set-up and which requires more active coöperation of the schools of business. However, there is no clear cut line separating the two fields, and some courses could be given either by schools of engineering or of business. Thus the administrative set-up is to remain as at present with the present director in charge of the enlarged program and utilizing the same group of regional advisers. At this meeting it was recommended that because of the increased scope of the program the name should be changed to "Engineering, Science and Management Defense Training."

An accurate appraisal of the Engineering Defense Training program is impossible at this time, since it has been in actual operation only about one-half year. Reports from the Army, Navy, O.P.M., and industry indicate that it is most helpful in meeting a need for technological talent by supplementing the output of engineering colleges by training large numbers to act as assistants to engineers, by up-grading employed engineers for more effective service, by retraining engineers for special defense employment, and by placing at the disposal of the armed forces facilities for supplying to commissioned officers specialized engineering knowledge. The U. S. Office of Education has had an opportunity through its contacts with the Army and Navy to aid in protecting engineering teaching and research staffs from serious depletion. The engineering colleges are benefitting by this program, in that they are able to make good use of their special facilities in the interest of national defense while acquiring at Government expense up-to-date equipment. They are also benefited by bringing their teachers into close contact with industry, and by developing effective coöperative relations with industry and government. The most important by-

products of the Engineering Defense Training program are a better understanding of the problems of industry by engineering colleges and a closer relationship between government and engineering education.

By GEORGE W. CASE *

The results to date of the Engineering Defense Training program apply largely to industry and were made possible by the effective work engineering teachers and men in industry have been doing for years in engineering education. While the engineering schools have taken the initiative in serving industry, they have waited for the Army and Navy to specify the kind of assistance they have needed in training their technical personnel. This experience should bring about closer coöperation between the armed forces and the schools in the future.

The first shortage of technically-trained men to be brought to the attention of the U. S. Office of Education by our armed forces was for explosives inspectors needed by the Army. An effort to have schools offer training courses to meet this need brought out the fact that only a few schools had faculty members prepared to give such instruction. It was first necessary, therefore, to train instructors. With the aid of Ordnance officers and a few civilians who had maintained their interest in this important defense field, a course was planned and offered by Washington University, St. Louis, under the direction of Fred Olsen, research chemist for the Western Cartridge Company. Thirty-three institutions coöperating in the E. D. T. program released members of their chemistry departments who had specialized in organic chemistry to take this course. Upon completing it they returned to their institutions to organize classes in the Chemistry of Powder and Explosives for the training of explosives inspectors. Such courses are now being given in about 40 colleges; it is estimated that these will turn out approximately 400 trainees per month, enough to meet the need for inspectors in this field.

A method of training was developed for these explosives courses that should prove helpful in meeting situations where additional training should follow the completion of class instruction. Due to the danger in the handling of explosives by inexperienced persons it was considered inadvisable for the colleges to give much of the laboratory work needed to familiarize students with explosives

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inspection practices. The plan, therefore, is to bring the students up to a given level of knowledge of procedures which can safely be taught in school laboratories, and then to pass them on to arsenals and manufacturing plants for experience training, which can be given more satisfactorily on the job. Since the content of all courses is much the same, this experience training can start alike for all trainees.

A similar plan is being studied for the training of Navy officers to direct the operation of diesel engines. The need for officers with this training has become acute, since a large percentage of the old and new vessels being acquired for the Navy are diesel-engine driven. Although the need is pressing, it has been tentatively decided that on the completion of courses in diesel engineering set up under the E. D. T. program the officers will be given experience, in a junior capacity, on diesel-equipped vessels before receiving their regular assignments. This program requires that the training given by various institutions in diesel engineering for the Navy be as uniform as possible.

In addition to the diesel courses, the Navy has officers attending E. D. T. classes in aeronautical engineering, aircraft engines, sound range equipment, naval architecture, and marine engineering; about 700 officers are enrolled in all courses. The Army has detailed officers for training in the operation and maintenance of aircraft, mapping, and the operation of sound range equipment. Although the total number of Army and Navy officers enrolled in E. D. T. courses this year has been relatively small, it is expected that this number will be greatly increased during the coming program.

E. D. T. courses given to eliminate bottlenecks in industry have covered a wide range. In general, they fall under five broad headings: Fundamentals; sub-professional subjects, including drawing; engineering design and similar highly technical courses; inspection and testing; production. The number authorized for training is about the same for each group, approximately 25,000.

Of these, the fundamental group is the only one requiring explanation. It includes instruction in the underlying theory of mechanics, thermodynamics, and other subjects to introduce young engineers to fields other than the ones in which they have been trained; to give to employed men a better understanding of the principles underlying the work they are doing or the job immediately ahead of theirs; and to furnish a foundation training for recent high school graduates in order that they may be employed in the elementary operations that are a part of engineering.

The fundamental courses have met the requirement set up for all E. D. T. courses that they up-grade men on the job or prepare

for immediate employment in work of an engineering character. It has sometimes been difficult for engineering teachers, under the pressure of requests for training, to see why any subject in a regular engineering curriculum cannot be used as an E. D. T. course. Further thought, however, usually clears up the difficulty. Analytical chemistry, for example, is a good course to teach in a chemical engineering curriculum, but it is not an engineering course when taught to train high school boys just graduated to make routine chemical analyses. Again, there is a difference between accounting in an engineering curriculum and accounting to train accountants. Most of the preliminary proposals that have been disapproved, or withdrawn after reconsideration by the institution, have been for training in activities that are not engineering.

Most E. D. T. courses are quite similar to those found in undergraduate engineering curricula except that the practical aspects of the material are more greatly emphasized. This emphasis is to be expected, since the purpose is training for immediate employment rather than education to meet the varied problems that will confront the student in professional life.

The number of E. D. T. courses that would qualify as graduate courses is small, but is likely to be larger in the 1941–1942 program. It is reasonable to assume that the most obvious needs this year were on the undergraduate level.

Proposals are of considerable importance in the E. D. T. program and, although the procedures in preparing them and in handling them after they reach Washington are much the same as will be found in the office of a practicing engineer handling contracts, they will bear listing in order to bring out certain matters for discussion. This discussion may also explain why authorizations to proceed with courses are sometimes not received as promptly as expected.

When a school wishes to give an E. D. T. course it prepares a proposal outlining the condition under which it is willing to proceed. Since there are a number of uncertainties that cannot be resolved at this time, this is called a preliminary proposal. It contains estimates as to the number of students who may be enrolled, the cost of organizing the course, the cost of additional equipment needed, and the cost of conducting the instruction outlined. It also indicates the probable or necessary preparation to be required of entering students, the defense need to be supplied, and the names and qualifications of the instructors. When the latter are regular members of the faculty, their names, rank and department are sufficient; otherwise a statement as to their individual training and experience should be given.

This preliminary proposal is submitted in duplicate to the U. S. Commissioner of Education, constituting a request for his authorization to give the course under the conditions named. When it arrives at the E. D. T. office in Washington it is properly stamped and recorded. It is then passed to an analyst who computes the unit cost and notes on the original copy any unusual factors that may require further consideration. This inspection is checked by a second analyst, and the proposal is then passed to the person whose responsibility it is to recommend approval or disapproval. The action taken is based on several considerations: Whether the course comes within the intent of the law; whether there is a need for the training; whether the course is well planned to accomplish the desired purpose; whether staff and equipment are adequate; whether the unit cost is reasonable. The list of accredited curricula in the annual report of the E. C. P. D. has been of great help in considering course approvals. If the E. C. P. D. accrediting program accomplished nothing else than to prepare the schools to render better service in this emergency its cost and the time devoted to it have been fully justified.

When it is decided that a preliminary proposal meets the conditions set up for the E. D. T. program it is recommended for approval. This action is sometimes preceded by considerable telegraphic correspondence with the institutional representative when adequate information is lacking. The recommendation is then checked by other members of the staff and, when an agreement is reached, the proposal goes to the Director for approval or disapproval under the authority delegated to him by the Commissioner of Education.

If the preliminary proposal is approved a formal authorization to give the course is prepared, attached to the duplicate copy of the proposal, and mailed to the institution. Telegraphic notice is also given if needed. Since May 20 all authorizations have been made by wire so that the institutions could proceed promptly with the organization of summer courses.

A duplicate copy of the authorization sheet is attached to the original copy of the preliminary proposal and sent to the accountant, who earmarks the funds needed to offer the course and then sends the document to the file.

After the course gets under way a final proposal is prepared containing more complete information about the course than could be given in the preliminary proposal. This follows much the same course through the Washington office, except that, after approval, the accountant prepares a voucher for the amount requested for the operating budget. This is initialed by the Director and the

Chief of the Division of Higher Education, signed by the Commissioner, and sent to the U. S. Treasury, which sends a check to the institution. The approval of final proposals presupposes that the institutions submitting them have sent in properly executed plans agreeing to offer E. D. T. courses under stated conditions.

Final proposals after certification for payment are filed as records showing what funds have been provided and the conditions under which they are to be expended. A step of particular interest to Institutional Representatives is taken in the accountant's office. When a voucher is prepared on the basis of an approved final proposal, the amount earmarked under the corresponding preliminary proposal is cancelled. That is why new preliminary proposals are necessary for repeat courses and for additional sections of a course set up after the final proposal has been submitted.

Certain terms used in the Act providing Federal funds for E. D. T. courses deserve more thoughtful consideration than they sometimes have received. They are:

(*a*) "Short engineering courses of college grade."
(*b*) "Designed to meet the shortages of engineers with specialized training in fields essential to the national defense."
(*c*) "Not to exceed twenty per centum of the amount allotted to any school shall be allotted to it for purchase or rental of additional equipment and leasing of additional space found by the Commissioner necessary for carrying out the approved plan."

"Short engineering courses of college grade" signifies that the courses are to be of the kind that are termed engineering courses by persons associated with engineering education in a professional manner, and of a grade offered in engineering curricula leading to degrees. This statement means that students who are enrolled in such courses should have at least the minimum preparation required by engineering schools for entrance. We are all familiar with this standard. Such preparation may have been obtained in school or out of school, but it should be determined that the applicant possesses it before he is enrolled.

The term "courses designed to meet the shortage of engineers" has been interpreted to mean that the instruction should be designed to prepare for immediate service. Certain subjects like chemistry, mathematics, and physics can be given under the E. D. T. program to employed persons to up-grade them for advanced work, but do not qualify when proposed as preëmployment training to recent high school graduates unless combined with other subjects, such as engineering drawing, that prepare the trainees for immediate employment.

Three points in connection with allotments for equipment and space deserve attention:

1. The 20 per cent limitation applies to the total cost of all courses in an institution's program, and not to the cost of each individual course. This means that a course can be approved in which the cost of equipment exceeds 20 per cent of its cost, if it is offset by other courses at the same institution for which the need for equipment is less than the allowable proportion. However, at no time can funds be sent to an institution to be expended for equipment and space in excess of 20 per cent of the total cost of all of its courses approved to date.

2. Equipment and space is defined as additional equipment and additional space. Congress assumed that schools which offer E. D. T. courses possess these facilities to meet the needs of their regular students, and merely need to supplement them to care for the added number to be trained for defense. Utilization of Federal funds to build up laboratories in branches of engineering in which a school has offered no previous courses is not contemplated in the Act.

3. The Act provides that equipment and space obtained for E. D. T. courses shall be such as is found necessary by the Commissioner for carrying out the institution's approved plan. This responsibility has been delegated by the Commissioner to the Director of Engineering Defense Training. In the practical operation of the program, while a list of equipment and a description of the space is requested in the preliminary proposal, it is realized that at times it may not be possible to furnish this information before the number to be enrolled is known. In the rush to plan courses, arrange for instructors, prepare preliminary proposals, and keep abreast of regular institutional duties, something has to wait. Many preliminary proposals have, therefore, been approved without full information given. When the final proposal is prepared, however, the enrollment is definitely known and there has been time to determine needs. Full information about equipment and space must be included in the final proposal before it can be approved, so that the Commissioner and the Director have the opportunity to determine the need and grant approval of such expenditures.

The Engineering Defense Training staff now numbers fourteen persons with professional rating, most of whom have had at least twenty years of experience in engineering practice and education. This staff is taking every precaution to guard institutions against inconvenience and loss. It appreciates the fine coöperation it has received from engineering faculties and from men in industry who have taken part in this program.

MATHEMATICS OF ENGINEERING*

By E. R. HEDRICK

Vice President and Provost, University of California

I am glad to be able to speak on Mathematics of (and for) Engineering in a General Session of this Society rather than before the Mathematics Section, both because I wish to appeal to those of you who are primarily engineers, and because I think that talks to my fellow-teachers of mathematics may be carrying coals to Newcastle.

I wish to emphasize the need for action to offset the tendency toward degeneration in the secondary school—a degeneration that is called "progressive," and it may indeed be so. We are faced today with emergency which requires much engineering skill. Young men—young people of both sexes—have been pampered too much in every phase of life, and particularly in the schools. Education has become soft. Men have preached that youngsters (and possibly also oldsters) should not do anything that they do not wish to do; nothing hard; nothing unpleasant; nothing that requires persistence and application. In the present world emergency, we need concerted action, with special emphasis upon engineering abilities, more broadly upon ability to think clearly about quantities. It is high time to demand that education become realistic, that soft habits be discarded, that youth learn how to handle the problems of engineering, of the actual world, of life in our civilization. Only thus may we hope to *save* that civilization.

Much of engineering deals with quantities and the relations between them. Quantities and their relationships form an indispensable part of the modern world. Life in our civilization is bound up with quantities and relations between quantities.

Yet educators have been progressively banning mathematics from school programs. They say that it does not affect life. They say that it is not of primary value to Society. But mathematics is, and of a right ought to be, training in thinking about quantities and the relations between them. If there are questions that occur in life and in Society more frequently and more insistently than do those of quantitative relations, I do not know what they are. If

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any man says that mathematics is not directly necessary to life or to Society, I believe that he is ignorant either of mathematics, or of life, or of both.

I shall pay some attention today to the reasons for this situation in our schools and to recommendations to you of ways in which you may help to correct it.

My reason for discussing secondary-school mathematics is that our teaching of mathematics in colleges is vitally dependent upon it. In addition to some factual information, which we might furnish by quick courses in college, there is a need for habits of thinking about quantities which are even harder to form in quick review courses in college; *time* is required to form correct habits.

The first thought may be that we can secure the necessary work in secondary schools by fixing our entrance requirements. This method, moderately successful in the past, cannot be depended upon. Many schools have stripped their offering in mathematics to the lowest minima, and they have introduced methods and courses which are below old standards. Moreover, school advisors often throw their influence against mathematics. Unless a child has formed a strong intention to be an engineer, he has not much chance to begin mathematics early in the high school. Under such circumstances, strong entrance requirements result in keeping many bright boys from entering engineering schools, if their choice of a career is not made in their very early childish years.

Indeed, the shoe is now on the other foot. Demands are being made on universities and colleges that students from high schools whose courses are inadequate, be admitted without prejudice. The claim is made insistently that any requirement of mathematics is an interference with the freedom of the schools and is called an effort to dominate.

How far this tendency has gone, and its effects upon habits of thinking, appears strikingly when tests are given in Freshman classes. Even among those who have chosen engineering the results are quite appalling, and (I think) beyond the belief of those of you who have not participated in such tests. My own practice was to set a test after about ten days of review, restricting questions to the type that would be proper in the first half-year of a real high school.

I shall not quote my own experience. A similar test set in the University of Kansas and 28 other colleges in Kansas, is reported by Professor U. G. Michell in an illuminating article entitled "Decimals and Democracy" in the *University Newsletter* of March 1, 1941. Another account is published by the *Bulletin* of the Kansas Association of Teachers of Mathematics for October, 1940. Tests were set in elementary arithmetic and in elementary algebra by

these 29 colleges in Kansas. A total of 4317 students were tested. Of these, 59 per cent (2463 students) failed on the question: *Express 7/8 as a decimal fraction.* Only 1545 (*i.e.* less than 36 per cent) could tell which of the numbers 7/15 and 11/25 is the greater. This is distinctly less than the 50 per cent score that would have resulted from pure guessing. I shall not burden you with many details; you can find them in print if you wish.

In Algebra, 93 per cent (3876) failed on the question: "Add $x + \frac{1}{x}$," and 28 per cent (1156) could not add 3/5 and 4/7. Again 25 per cent (1035 students) failed on the question: "If one pencil costs p cents, what will q pencils cost?"

Even more significant, however, is the difference between certain large high schools. Counting only the six largest high schools in Kansas, the best one (with a total of 78 students taking the test) made an average score of 8.6 correct out of 20 questions, which is reasonably poor. But the record of the worst of the six (with 69 students taking the test) was 0.9 correct out of 20 questions. Thus the students from one large high school made an average record exactly one-tenth of the record of those from another. If you have doubted the seriousness of the effects upon students of the attitudes and practices of high school teachers, this comparison—ten to one—should convince you. If you want students with reasonable abilities to think about quantities, it behooves you to bestir yourselves about all this.

I will admit that part of the difficulty is due to poor teaching by teachers of mathematics. But much of it is due to policies of superintendents and principals and so-called curriculum experts. One persistent practice in almost every State is that principals employ teachers to teach mathematics who have not specialized in mathematics in college. Not much can be expected from such teachers. Other advice which I would give to high school teachers of mathematics will be evident from what I shall say about mathematical teaching in colleges.

We need heart-searching and some change of attitude on the part of *college* teachers of mathematics. At least college teachers are uniformly reasonably trained in mathematics. Too often, however, college teachers of mathematics have not a sufficient interest in or knowledge of engineering, nor even of physics and mechanics. Much that I shall say in criticism is due to this ignorance of engineering and related subjects, and to the fact that too great emphasis is placed upon the interests of what is called *"pure"* mathematics. I hold, however, that even the interests of "pure" mathematics are served best by the very things which I shall emphasize as needs of engineering students.

One fatal mistake, especially of young teachers (and much elementary college teaching is done by young men), is that they talk "over the heads" of their students. It is hard even for experienced teachers to realize that there exists such ignorance of arithmetic and of elementary algebra as that indicated by the tests which I have described. If such tests are given, teachers will realize more fully what their students do and do not know. Hence the tests serve a double purpose, for they classify the students and they also warn teachers against over-expectation. It is enough for me to say that we ought to start with students wherever we find them, rather than to proceed on preconceived ideas of what they should know.

My other main emphasis is upon the very meaning of mathematics, which is so often forgotten. It is, and should be always, training in thinking about quantities and about relations between quantities. Nothing can be of more importance to engineering, as I am sure all will agree. But what is equally true is that nothing is more vital to "pure" mathematics, despite the fact that it is so often forgotten. I shall illustrate the difference in specific topics presently. Just now I may say that we call quantitative thinking also *functional* thinking, since if one quantity depends upon another, we say that the one is a *function* of the other.

Aside from these two general principles, I do not wish to urge great changes in the customary traditional required courses in mathematics in schools of engineering. The "norm" of current practice will probably remain. Some additional work, principally in vector analysis and in differential equations will be added, particularly for electrical engineers.

Nor shall I dwell upon the various forms of organization, such as "combined" courses. I rather think that the important thing is to make sure that all of the really important elements of traditional courses are taught somewhere along the line, and I shall not quarrel with any man's hobby for organization into wholes or pieces, *if he does that.*

How shall we know which are the "important" topics whose retention I have demanded? First of all, if a topic is really used in engineering, or in related sciences, it is important and should be kept or even given greater attention. Secondly, if a topic fits in with that primary purpose of all mathematics, the training in quantitative thinking, it ought to be kept. I shall illustrate each of these by examples, for such examples occur in every mathematical course that is worth anything. If all topics which have these characteristics are kept and all which have neither characteristic are discarded, I shall have no quarrel with the content or with the arrangement, no matter what it may be.

That traditional courses contain topics which meet these demands and others that do not meet them is evident from the beginning. In trigonometry, for example, aside from the obvious desirability of solution of triangles, we have had too much attention on the so-called "identities" problems. Long lists of identities appear as problem lists; they try the soul, but serve little purpose which I have been able to discover, beyond those exceedingly simple identities which I need not mention and which you all know. On the other hand, not enough attention has been given to the functional side: to the drawing of graphs of the trigonometric functions, with such obvious things as the sum of sin x and sin $2x$, for example. With no knowledge of electricity, the student will comprehend sin $2x$ as the musical octave, and the combination as the picture of a tone. Such things will give a beginning of knowledge both of physics and of mathematics which are of great importance in engineering also. I need only mention the tremendous importance for engineering, physics, and pure mathematics of Fourier series. No student of mathematics would contend that the so-called "disciplinary" value of the "identities" problems has any such value, either to pure mathematics or to its applications.

In algebra I may cite the detailed solution of cubic equations as a topic of little merit. Simultaneous quadratics lead to equally fortuitous and relatively useless tricks. By comparison, the solution of equations by plotting the right side as a function is of real use in many engineering situations and it is also of great mathematical importance.

In analytic geometry far too much attention has been given to the general equation of the second degree. To be sure, the conic sections are of primary importance in engineering and in mathematics, and they ought to be studied exhaustively. But the general equation of the second degree, with its reductions, is of doubtful value to engineers, and it is also of surprisingly little value to mathematicians, except in one small corner of mathematics. Far more important is the study of such functions as $y = x^3$, $y = x^n$, $y = \sin x$, $y = e^x$, and their combinations. Here again the functional character of the things studied is of far greater importance both to mathematics and to engineering than are the so-called disciplinary topics. There is plenty of "discipline" in the topics I have mentioned.

In the Calculus, the difference created by such an attitude stands out on every page. I would guarantee to discover within a few moments, in any text or in any class, whether the instructor or the textbook had more interest in "discipline" or in functional thinking. Is the teacher or the textbook more interested in *rates of change* (*i.e.*, in velocity) or in finding tangents to conic sections?

Is the emphasis on problems like $x^{\frac{2}{3}} + y^{\frac{2}{3}} = a^{\frac{2}{3}}$, which is an ingenious puzzle, or on such functions as $e^{-x} \cos x$? Is integration regarded as a pleasant crossword puzzle or is the emphasis on the findings of limits of sums, such as those that occur in water pressure? Such differences in emphasis abound in the Calculus. We should see to it that every topic such as acceleration and moment of inertia, which are of vital importance both in pure and in applied mathematics, is retained and emphasized, at the expense, perhaps, of such curiosities as the finding of tangents from an external point to a conic, or diameters, or poles and polars. The basis of choice should be in all cases the criteria that I have mentioned: first, the usefulness of the topic in engineering and the related sciences, secondly, the question of the functional character of the topic.

In differential equations the emphasis on meaning as opposed to memorization of a few forms leads to similar conclusions. That a rate of change of a quantity is proportional to that quantity is fundamental in a vast variety of applications. That a second derivative of a quantity is a function of that quantity is meaningless, and solution by multiplication by the first derivative is a blind trick, unless the student becomes aware that the resulting integral expressed in terms of distance and time, is essentially the kinetic energy. To bring out this solution in terms of kinetic energy is of the utmost value both to pure mathematics and to engineering.

Perhaps the illustrations that I have given will suffice to explain why I believe that the principles I have stressed—applicability and functionality—are of primary importance throughout mathematical teaching, both to mathematics itself and to engineering. Once alive to these things, the teacher will find a need for choice almost on every page, and certainly every class-hour.

Indifference and/or ignorance regarding all these things has brought mathematical teaching into disrepute, not only in the secondary schools, but also in colleges and universities. Interest in one's own specialties, adherence to theories of disciplinary value, and sometimes plain laziness, have led teachers of mathematics to assigning long lists of dreary problems that are often as void of value to pure mathematics as they are to its applications. Insistence upon memorization of formulas is an attendant sin, in which professors of engineering subjects have often aided and abetted poor teaching of mathematics.

Maybe I should be more polite than to intimate that professors of engineering have encouraged and abetted poor mathematical teaching. Will you join me in trying to improve it? For one thing, will you frown upon memorized formulas that are not understood? Too often such memorization is praised, even when it is apparent that no comprehension goes with the formula.

Comprehension, and ability to think correctly, chiefly about quantitative relations, are more important to modern engineering (and also to mathematics) than any amount of blind memorizations. Quickly to pass over the thinking that is involved in a mathematical part of an engineering problem is all too common. Is this not a sin against good engineering as well as against good mathematics?

Another crime that is all too frequent in engineering teaching is to over-simplify a topic that should be treated mathematically. A simple illustration is the effort to study laws of falling bodies without the calculus, or to discuss mechanics without recognizing velocity and acceleration as derivatives. A criticism of just such a case appears in *Science* for May 23, 1941, in an article on page 495 by Condon of the Westinghouse Research Laboratories; he ends by saying "In short, I hold the opinion that there is too much attempted mathematical treatment of physics in the beginning course, with resultant cutting out of interesting qualitative descriptions of phenomena, and artificial over-simplifications which make the subject obviously unreal, in order to bring it to the painfully low level of mathematical attainment of college freshmen. The remedy, obviously, is to resume the teaching of mathematics in secondary schools."

I hope very earnestly that such opinions, if not my own, will lead you to feel that you—engineers—should do something about this situation. Are you willing to help? What can you do?

I venture to suggest that you can do some things very speedily, and others, perhaps, in time. One of the immediate possibilities is to form closer liaison with the mathematical departments: after all, you will find them (believe it or not) *human*. They too know the seriousness of the present conditions and their minds are more receptive now than, perhaps, in times past. I suggest that joint meetings of mathematicians and engineers be encouraged, and that each group show the other wherein their difficulties lie. Chiefly, you engineers should show the mathematicians just what types of problems you do meet which require mathematics. They may show you their textbooks and ask you which topics ought to be most emphasized. Do not make the mistake of assuming, as one engineer did in talking with me, that "everybody knows" all the mathematics needed in your particular subject. It would do great good if some engineering texts could be placed in the mathematical offices: it would be enough to send old editions of books now superceded by newer editions; the old ones give a good idea of the types of mathematics actually in use. I do not believe that either mathematicians or engineers will fail to attend conferences such as those just suggested, if the effort is made in the right spirit. I do not

need to tell you that there are several ways of *ruining* such conferences.

Another thing that you can do is to arouse public opinion. First of all, you will find it very easy to gain enthusiastic support in departments of mathematics and the physical sciences. You may find it very easy to secure enthusiastic support in the so-called Parent-Teacher Associations. Very considerable rebellion is in the air, not only among parents but also among the rank and file of the actual classroom teachers.

On the other hand, if I have said that you will find enthusiastic support in such groups, I should say that you may find enthusiastic *enmity* in groups of principals, superintendents and curriculum-builders. You must be prepared, at least in some communities, for vituperative abuse. Perhaps you will be comforted by the companionship of parents and classroom teachers, who see to what depths of folly we are being—shall I say progressively?—led.

The time seems to me to be ripe. We know how much we need mathematical knowledge, that is, ability to think quantitatively, in the present emergency. Two results emerge. If those who teach mathematics either in colleges or in secondary schools, do not know that it is their business to teach *just this ability to think quantitatively,* they should be taken to task, and none too gently. You can do this.

In the second place, the public, certainly including parents and actual classroom teachers, are disturbed, if not rebellious, about the softness of present school curricula and school methods. The time has come to lead these distressed patrons of the schools, and to compel school authorities to restore proper mathematical teaching into the public schools.

I call upon you, in the spirit of this talk, to assume the task of such leadership. You can do it as we cannot, for they say that we are prejudiced and that we act only for our selfish interests. I know that the engineering fraternity can sway public opinion back to saner practices in the public schools. I pray that you will do this. I hope that mathematics will be restored to the schools. I hope that mathematics, both in schools and in colleges, shall be the type that contributes most to engineering, that is, the training in habits of quantitative thinking.

Discussion

C. Johnson, University of Detroit: It was a little difficult for me to keep from shouting "Amen!" at the opening remarks of Dr. Hedrick. A little over thirty years ago, I attended the University of Missouri expecting to be a civil engineer. I was

warned by the older students to keep out of Hedrick's mathematics classes. They said, "He will sidetrack you and make you a mathematician." After a month of sitting in his class, I had lost the ambition to become a civil engineer. I have no regrets.

Professor Hedrick spoke of the inadequacy of the secondary school teaching. Some years ago a professor of mathematics at an eastern university was amused when a freshman in his class had the occasion to reduce the fractian $^{16}/_{64}$ to its lowest terms. The student got the correct answer by cancelling the sixes! He happened to hit on one of the four fractions on which that will work. I told that story to a high school teacher of mathematics who had not had any college mathematics. She was not amused. She seemed to think it was perfectly proper that the student got the right answer.

A former colleague of mine, now on the faculty of an eastern institution, told me of a man in biology who came to him and said that he had been reading an article in biology in which he had the equation $dy/dx = x$. "I know my calculus enough," the young man said, "to understand the first line. The next line I couldn't understand."

It was $y = x^2/2 + c$.

Said the young man, "I coundn't understand where that came from. In the first it seems easy to see that if you cancel the d's in the fraction and clear fractions you get $x = x^2$. But in the second the two is a misprint and where the devil did that "c" come from!"

Professor Hedrick mentioned the competency of acceleration. A very widely known and very popular textbook in mechanics (I shall not name it) in the first edition showed by diagram that the total acceleration is the result of the horizontal component and vertical component. In other words total acceleration is along the velocity. That error was called to the author's attention, and it took three editions to correct it.

I have a daughter who has just finished her third year in the university. She was not a diligent student in high school. She said, before the expiration of her first year in her college, that she and others of her class were expressing to one another their resentment that the high school teachers had not required more diligent work of them. Within a year they were angry because the high school curriculum had not put more pressure on them.

In a certain institution in the eastern part of the United States, a young man in mechanics was asked to find the superelevation of the inner rail of a railroad track given the maximum velocity of the train and curvature, and he read the formula. He got twenty-

two feet four inches! The instructor asked him if it didn't impress him that the remark was absurd. His answer was, "Sir, I never think on an examination. I haven't time!"

L. W. Clark, Rensselaer Polytechnic Institute: I had come here this morning expecting to hear a phase of this discussion brought up, which I haven't heard, and I am just going to throw this out in the hope that it will perhaps bring out a little discussion from some of the men here. The question is as to where mechanics should be taught to the engineering student; whether it should be taught by the separate departments such as mechanical engineering and electrical engineering; whether it should be taught by the department of mathematics as it is in my places; or if a separate department of mechanics is desirable.

I have very decided opinions on this myself. At Rensselaer for many years the subject of mechanics was taught by the civil engineering department for no reason other than that the civil engineering department was originally the only one there. About two years ago that method was dropped and a separate department of mechanics organized, and we are all unqualifiedly in favor of such a method. In the last two years I have had communications from other institutions (I think from three institutions) asking our opinion as to whether or not we feel that the subject of mechanics should be taught in a separate department or can best be handled by the mathematics department as is being done in each one of those cases.

I would almost go so far as to say that mathematics ought to be taught by engineers who have become mathematicians. That I don't think is quite as important. I was really hoping that this question would be discussed—as to how our mechanics courses should be given. Personally, I am unqualifiedly in favor of a separate department in mechanics. I should like very much to hear the opinions of some other men on this subject.

D. C. Jackson, Massachusetts Institute of Technology: This touches a matter of long conflict that I have gone through in past times, and I have no doubt that Rensselaer, for their institution, have done the right thing.

Let me remark that the phraseology in which the argument was expressed is purely superficial. It deals with what departments such and such a subject should be taught by or in. In fact, the only point of importance is the man who is to have charge of this teaching and supervising. It does not make a bit of difference as to what department he is located in. I leave that idea with you as an answer to the gentleman.

PHYSICS IN THE ENGINEERING CURRICULUM *

By E. U. CONDON
Associate Director, Westinghouse Research Laboratories

Although asked specifically to talk about physics in the engineering curriculum, I would like to discuss a larger question—namely the deplorable lack of close association that exists between physicists and engineers. If we can do something to remedy that situation, probably the curriculum questions will be solved more readily.

Individual experiences differ greatly. Having no facilities to carry out a poll, I must speak of my own personal impressions without claiming proved general validity for them.

Do I exaggerate when I speak of the great separation between engineers and physicists? I think not. I have been an active member of the American Physical Society for fifteen years. To the best of my memory it has not, in that period, met jointly with any major engineering society. Nor has the American Association of Physics Teachers met jointly with this Society for the Promotion of Engineering Education. From this one might draw the conclusion that physics and engineering have nothing in common. Or can it be that the professional societies' activities are not adequately representing true profession interests? But if that is so, why is it so, considering that the societies are run by their members, and therefore lack of close association of the corresponding societies merely reflects the customs and habits of the professional groups who compose them?

Now, of course, I am not insinuating that the physicist and the engineer are at sword's points or not polite to each other. But they do move in separate worlds and this is the situation I would like to see corrected.

First and foremost, the greatest mistake we make is to act as if physics and engineering were quite distinct intellectually. Actually the subject matter is exactly the same, the professions differing only in regard to their attitude toward this subject matter. The physicist investigates the inter-relations of matter and energy with primary emphasis on a logical integration of our knowledge of the physical world into a complete whole. Engineering utilizes this

* Presented at the 49th Annual Meeting, S. P. E. E., University of Michigan, June 23–27, 1941.

same knowledge in the planning and operation of projects designed to satisfy human needs.

What is the basis for conflict or at least of mutual misunderstanding here? There is plenty, I am afraid. The physicist feels that his primary responsibility is to the fundamental science. And therefore he does not feel obliged to order his investigations with regard to their probable usefulness. If a given topic looks interesting and important for basic science, the physicist follows hotly after it without regard to whether it is likely to prove useful soon in engineering.

Doing so, he neglects to investigate fully topics whose usefulness is already apparent. Engineers are apt to resent this and to regard physicists as impractical fellows who never finish anything. The physicist feels that once the broad principles and some specific details are discovered he ought to be allowed to leave the complete working out of application details to the engineers.

In addition to his love of chasing after the newest developments, I think there is another reason why physicists do not like, as a rule, to devote their energies to engineering problems. They are keenly aware of the totally inadequate financial support of long-range fundamental research that we have had in this country. It is not that the physicist is really unfriendly to the development of applied science—it is simply that he is always aware of the danger that the larger progress of science will be hampered if the engineers have too large a say in determining the direction and emphasis of research in physics.

When the importance of long-range fundamental research in physics is more widely and more fully recognized, than the physicists will be more sure of their position and will be much happier about devoting a good share of their effort to engineering problems. We may hope that that time is not far off when we take note of the appearance of liberal programs of fundamental research sponsored by private industry—such as that of the Research Laboratories of the Westinghouse Electric and Manufacturing Company, for example.

I am quite sure that many of the "elder statesmen" of the American Physical Society have actively resisted close professional association of the physicists with the engineering groups because of what they consider to be the danger that the supporters of disinterested fundamental research would be a small minority group among a vast horde of practical men without scientific ideals, but I think I see many signs that this attitude is not going to be held much longer and would like to do everything I can to change it.

For one thing, in recent years there has been, among physicists, a growing realization that they should do more to cultivate the

topics of their subject which find engineering application. The movement had its origin simply in the desire to open up new outlets for employment of physicists during the depression. It has, I think, surprised many academic physicists by showing them that engineering problems can be just as fascinating and challenging as those of academic science. It has given rise to a stimulating and vigorously edited research periodical, the *Journal of Applied Physics*.

This trend is being given an enormous push by the defense program. It has been recently estimated that about one third of the physicists of America—including virtually all of the leading academic research men—are now engaged on military and naval research projects. Thus many men who have never before given a thought to practical application of their science are being brought into an intimate acquaintance with the special problems and methods of engineering research. One may confidently hope that the defense program will do much to bring physicists to a better understanding of the engineering outlook.

Nevertheless, I think this applied physics movement has been marred by too much of a desire to set up an antithesis between the applied physicist and the engineer. You are an engineer if you graduate from a college of engineering but if you go into industry after majoring in physics in an arts college, then you are an applied physicist.

So new a trend is it for physicists to go into industry that many of them are quite anxious to continue to be clearly labelled as a physicist. We should take the point of view that all engineering is applied physics and all applied physics is engineering. It will be much better if the physicists who enter application work will, with all due pride and humility, accept their place in the engineering profession instead of trying to form a separate and aloof minority group of applied physicists. For what, after all, is today the tenuous distinction between applied physicist and engineer? It seems to come down to this: the applied physicist works with results and techniques not known to science, say twenty years ago, whereas the engineer confines himself to the application of the older knowledge of physics. Surely no good can come of a distinction like that!

On the side of the engineers, I think that they are approaching in recent years more closely to a basically sympathetic association with the physicists. This is undoubtedly due to the rapid development of the research idea in engineering and the tremendous expansion of industrial research programs we have seen since the first World War.

As closer association of psysicists and engineers continues to develop, improvements in the position of physics in the undergraduate engineering curriculum will automatically follow. But first what is this position?

As you all know, the engineering curriculum is extremely crowded. Everybody wants to put something in and nobody—save probably the students—wants to take anything out. I am afraid most of the engineering graduates of today are going through with little or no contact with the physics department beyond the introductory course in general physics. They get usually nothing but a brief one-year course which ranges over all parts of an enormous intellectual territory. The result is often an over-simplified and superficial treatment which is later supplemented by more adequate handling of the separate topics in courses given in the engineering college. True, the boys have a few electives, but they are worked so hard in the engineering subjects that most of them crave something a little softer than advanced physics. And besides, many of them really want to use them to follow the good advice that is so often given them—to take a little work in the humanities. Another reason why the engineering students avoid the advanced physics courses, I think, is because there is so much overlapping in subject matter with what they get in their engineering courses.

Naturally, as a physicist I think that there should be more physics in the engineering curriculum—there is no "man bites dog" news about that. But since I think that engineering and physics are intellectually one field, just what do I mean, then, by putting more physics in the curriculum? I mean that more of the basic subject matter should be presented from the viewpoint of the academic research physicist. More emphasis should be placed on critical basic understanding of every phase of engineering practice with a research outlook and less to the simple acquiring of skill in working out situations by handbook rules. This greater emphasis on basic science which I expect to see in the years to come should not, however, be brought about simply by squeezing in more separately labelled "physics" courses. That would only serve to continue to preach an antithesis between physics and engineering which is really not there.

The kind of change that I have in mind can only be brought about by a thorough-going introduction of the research spirit into the engineering faculty. This will call for solving some problems in university administration for generally speaking, the engineering faculties have not had the opportunities in free time or in equipment that have been provided for the basic sciences in the arts col-

lege. But by giving such support and by planting a few men in each engineering department who have been trained as research physicists, we can accomplish the kind of improved place for physics in the engineering curriculum that I would want to see.

When this has been done and when there is a corresponding closer professional association of physicists and engineers in industry, we shall see an orientation of all engineering instruction toward sound appreciation of basic science and away from contentment with the craftsman outlook of the traditional practical man. Physics will have permeated every part of the engineering curriculum and will be closely integrated with the application work in a way which will react to stimulate progress both in physics and in engineering.

CAMPUS SAFETY *

By C. W. BEESE

Professor of Industrial Engineering, Purdue University

The organized effort to reduce the social and economic losses through controllable accidents became increasingly effective with the growth of the safety movement in industry. Through the years of its development, it has gathered support among the public, in government, in industry, and among workers. In its infancy, the safety movement faced terrific obstacles, chiefly in attitudes of those affected by its evolutionary and almost revolutionary recommendations. Organized safety is now one of the most commanding factors with which industry deals and a safety recommendation demands priority attention.

From its beginnings in an attempt to decrease the terrific toll exacted by accidents in the steel industry, safety has spread and is still spreading into many other areas. Each year, safety programs become more effective. Sympathetic acceptance by the public, legal support from state and Federal enactments, intelligent and enthusiastic leadership from industry and increasing insistence from organized labor have generated a momentum which is irreversible.

Safety is no longer an inefficient, haphazard program. Analyzed and summarized experience points out a plainly recognized procedure. Industrial experience in safety programs includes, first, a striking and continuing reduction in the frequency and severity of accidents; second, the acceptance of a code of safe practices; and third, the development of a highly effective teaching procedure.

Striking as industrial results have been, there are still areas in the patterns of human activities where the answers to an undesirable accident record are not known or, if known, have not been effectively applied. The intelligence and energy of many agencies are being focused on the scandal of highway accidents. In spite of this, the fatalities in this classification in the United States alone exceed those due to bombings among the civilian population of England.

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The elements of a great many safety problems are duplicated in the campus situations which exist in American colleges and universities. Accident hazards in factory and mill have their counterparts in the laboratory and shop. Injuries through recreational activities are more likely to play an important part in the lives of the age group found in a university than among the population as a whole. The type of accident which is prevalent in the home is common in the dormitory. Apparently, the traffic accident is with us always and every where. The emphasis differs in specialized circumstances but otherwise the problem is the same. On the campus or off it, students, staff, and workmen are subjected to injuries due to falls, falling objects, burns, infections, explosions, and the use of hazardous tools and equipment. And an analysis of the fundamental causes lays the blame on the same offenders; carelessness, poor housekeeping, ignorance, and attitude.

Discussion

It was the original intention to bring to this group a pictorial presentation of a typical campus situation. Apparently this was justified through the author's experience in the importance of acquainting administrative officers with situations which, through long association have become acceptably satisfactory. On the other hand, the other fellow's troubles sometimes arouse sympathy but fail to guarantee a self-questioning approach to a problem which after all, faces each college administration. Further thought seemed to point out that the best use of time would come from a condensed discussion of—

(*a*) The justifiable emphasis on a campus program dealing with safety.
(*b*) The scope and purposes of such a safety program.
(*c*) The organization of an effective safety program.
(*d*) The elements of a well rounded approach to accident prevention; and
(*e*) The results to be expected.

How much Safety?

Through the United States Department of Labor, an organized safety advisory program is available to American industry engaged in defense production. When a defense contract is let, a volunteer who is skilled in safety administration is delegated to call on the contracting manufacturer and offer his services. He makes his visit with no authority except to enter the plant, but his report

exerts a sharp influence that may make itself felt in undesirable situations.

Comments from those in charge of the visitation program emphasize that almost without exception, they find that the industrial organization of a thousand men or more has an active safety program with a well trained director and suitable assistants assigned to a full time program of accident prevention. Smaller plants assign safety as a major responsibility to persons who may have other duties also. It is in the small organization of a hundred men or less where real difficulties present themselves because safety is no one's job where it is everyone's job.

How different the recognition by the typical university of the size and importance of an accident prevention program.

A typical engineering school in the middle west has several thousand students who correspond to workmen in their relationship to safety. Over them are from two to twelve hundred teachers and administrators who correspond to the supervisory personnel in industry. In few instances do universities use a full time safety engineer and recognize the importance of his program to the extent of giving him functional authority in his field.

It is as yet impossible to measure statistically just how many accidents occur on a campus. Except in isolated areas, records are almost nonexistent. This is not true in industrial or public safety. Analyses of accidents, their causes, frequency and severity, furnish a basis of comparison that enables a safety man to weigh the effectiveness of his program and recognize those places where his immediate efforts should be concentrated.

A determined effort at Purdue University to have all accidents reported to a central committee for purposes of analysis and recommendation, has placed on record enough injuries to justify a quick opinion that there must surely be a direct correlation between the activities of a safety committee and the number of accidents. At the same time, it is definitely probable that the record is woefully incomplete. An interview within the last month with a prospective candidate for a stenographic position, disclosed that during the current school year there was a period of enforced idleness from a university job due to a fractured wrist resulting from a fall in a university building. In another case, a slippery floor due to casual water in a connecting tunnel between dormitories caused a fall which resulted in a fractured knee and ankle to an employee. In neither case has the accident been regulary reported.

It took many years for industry to accept the necessity of a complete statistical report. It should not take as long on the

campus because a good example already exists of the value of such information. In spite of the reasonableness of requiring accident reports, it is the author's experience that considerable resistance is encountered on the campus as well as in the plant. Until this is overcome and in more than a few isolated instances, it is impossible to define statistically the importance of the campus safety program. It is almost certain that both the frequency and severity of campus accidents are much worse than are generally realized, even by those who are most concerned.

One of the most interesting exhibits to be added to the safety file during the current year is a letter from a head of a chemistry department in a neighboring university. To quote: "We point with pride to an outstanding program of chemistry research over a period of twelve years without a serious accident." To the author's personal knowledge, there occurred in that department during the school year just closed and in the months just previous to the date of the above letter, two eye injuries, one of which resulted in the loss of sight. In that same laboratory, preserved in a pint jar by an instructor, are the miscellaneous parts of flesh and bones which once formed a hand destroyed in an explosion injury to a student who has not yet graduated.

Purposes of a Campus Safety Program

The safety program on a campus is as broad or broader than that encountered elsewhere. As in the factory, in the home and on the highway, it is of primary importance to reduce the frequency and severity of accidental injuries to a minimum. In addition to avoiding injuries to students and staff, the university as an educational institution can well afford to foster a training program in the field of safety. In a way this merely expands and continues the public school program. The student should leave the university and enter industry with an appreciation of his personal responsibility to promote safety, an elementary ability to recognize accident hazards and a knowledge of safe practices in specific situations.

Scope of Safety Program

The safety program concerns all of those who make up the body of a University. A college president recently commented that he was not concerned with the student part of the safety program. They were teachable. He was more concerned with the faculty and was convinced that this group would be the most difficult to train. Added to these is a sizable group engaged in repairing buildings,

maintaining grounds, and furnishing the services of housekeeping, heat and light. Experience indicates that the safety records of the latter group may not be too good. A complete safety program must include all these groups.

Organization of A Safety Program

It is true both in industry, and on the campus, that the success or failure of an accident prevention program reflects the attitude of top management. The responsibility of direct supervision over the details of the program may be and most frequently is delegated to someone else. When a staff man in charge of safety may temporarily do less than is expected of him, he can hardly go beyond the point where his management will support him. As a consequence, a safety program on the campus, as elsewhere, must be sold to major executives as an essential first step.

One safety man can exert his maximum effectiveness only if he multiplies himself through a safety organization. A central safety committee has the immediate advantage of placing an assistant safety man (or woman) in each major administrative area of the university. This committee, through its chairman, reports directly to the President or to his executive committee. It is made up of persons with a deep faith in the worth-whileness of a safety program and a willingness to preach safety in the face of indifference and opposition. The most desirable experience background that it is possible to get in members of the committee is industrial training in safety.

The major responsibilities of a central safety committee are:

(*a*) *Help the executive committee of the University develop a safety policy.* Such a policy shall fix the boundary of the safety program. It shall describe the major responsibilities of those who are given accident prevention assignments. It shall define the objective of the entire safety movement as it affects campus activities.

(*b*) *It shall appoint sub-committees.* It is desirable that each member of the central safety committee shall organize in his part of the university a committee of students and staff members. Since the functions of this committee are first, to gather information and second to form an assembly which will be used to absorb and then transmit safety information, these sub-committees need not be small. Twenty-five to forty persons from a major section of a sizable school are not too many. The sub-committee shall be trained by the chairman in safety procedures. They shall then be used as observers to discover unsafe conditions. They shall above all things act and

talk safety on all occasions. The importance of safety committees justifies at a later point, a further discussion of these responsibilities.

(*c*) *It shall set up and operate an accident reporting and investigating procedure.* One of the most powerful tools in an accident prevention program is the intelligent use of statistics. These data come from the experience of others and, more usefully, from the analyzed reports of accidents as they occur. The value of these reports depends on a number of factors, all of them controllable through proper organization.

Reports should cover *all* accidents. It is admitted that several definitions of the term "accident" are possible. Most states require filed information on lost time accidents to employees. Many industries keep complete records, as well, of injuries that require first aid attention.

A more widely applicable use of the term is to recognize accidents which may not result in injuries. Reports cannot do less than to cover the first category. Personal experience convinces that first aid information identifies many hazards that can be eliminated. Non-injury accidents are important warnings away from possible trouble.

In a campus program, it is important that all persons be included in accident reports. Responsibility for compensation resulting from injuries to workmen is a primary motive for keeping these records. Since payment for injuries is seldom involved in the cases of students, the introduction of accident records in these cases has been slow. Over and above this reason is the value of accident statistics as a medium for discovering the danger spots and laying out a plan of attack to correct them.

It is of some importance to discover the happy medium between too much and too little information. Too little information does not permit useful analysis. Too much information becomes an obstacle to willing coöperation from staff members who make out reports.

Accident reports may take many forms but should meet the requirements demanded of them. "How many accidents" is not, by itself, an important question to answer. As a minimum, the report should identify the injured person, describe the injury, make a complete record of the circumstances pertinent to the accident, attempt to point out the fundamental cause of the accident, fix the responsibility for it and be signed by a person in a position to specify and take steps to prevent a repetition of the accident.

In order that reports shall be complete, it is desirable that responsibility for them shall be delegated to a great many persons. The job is not a clerical one. It should be assigned in small, well-

defined areas to individuals responsible in those areas for the activities generally carried on there.

It is unusual if the introduction of a strict program of accident reports does not meet with opposition from laboratory and shop instructors. Such reports have some personal implications when the question of responsibility comes up. Simultaneous objections because "we have no accidents" and "it takes too much time to make out reports" are not infrequent. An attitude of willing coöperation comes from a diplomatic selling job on the part of the safety committee.

A central safety committee is the proper agency to receive reports and to follow through with their recommendations. This committee is also the logical group to summarize the reports and thereby measure progress from period to period.

(*d*) *The central safety committee shall operate a safety education campaign.* On no other item of its program, should so much emphasis be placed. A number of channels may be depended on to teach safety. Perhaps the best of these is the day by day emphasis on safety incidental to instruction in shops and laboratories. No safety campaign by a specialist is as permanently effective as the constant inclusion of safety as one of the inevitable considerations of any situation.

The general safety meeting should not be avoided. It is a source of inspiration as well as information. Led by an industrial safety engineer who has some of the characteristics of the spell binder, it helps maintain an interest and enthusiasm that are so necessary. Posters, signs, pictures, exhibits, and demonstrations are also essential.

(*e*) *The central safety committee shall conduct safety inspections.* Since appointments to a safety committee may be made to educate the appointee, some members may be more enthusiatic than experienced. It requires training to find hazards and to evaluate them as to the possibility of injury. Inexperienced observers overlook items outside of their familiar fields and pounce on other items, relatively less important.

Inspections should be made at regular, frequently scheduled intervals. They should cover all aspects of the safety program: traffic, fire, buildings, shop and laboratory equipment. Detailed check lists are available and are of first importance even to the skilled inspector. Inspections should result in a written report with a liberal distribution. It is important that inspections shall be made by a member of the committee only when accompanied by a member of the staff of the department responsible for the area which is undergoing scrutiny. To do otherwise undermines confidence in the fairness of the report. It is also important that the

report be submitted to the responsible head of the department before it is released to others.

In connection with a discussion of reports, it is worth while to mention the value of suitable illustrations. Pictures of undesirable conditions are a fair substitute for an inspection trip which may be difficult to arrange. They form a striking record of original conditions and subsequent improvements which in itself is a progress report more dramatic than words. Reënacted accidents, recorded in photographs, make effective posters because names, dates, and descriptive data bring the hazard close home.

(*f*) *To promote an adequate first aid program.* First aid involves several aspects. Minimum requirements are readily available first aid cabinets and persons trained in first aid procedures. Red cross training in first aid forms a valuable continuous program. Each shop and laboratory should have some one who may be relied upon to adequately care for injured persons.

The responsibility of the committee lies in advising in the selection and purchase of cabinets and supplies, supervision to see that they are maintained, and the organization and operation of first aid classes. Of greater importance, is a permanent campaign to insure the acceptance by students and staff that first aid treatment is mandatory in all injury cases.

Safey Standards

A detailed presentation of safety standards has little place in this discussion. Industrial experience has been codified by law and customs. Most of these standards may be applied without revision to campus situations. Such standards are available from insurance sources, state departments of labor and industry, technical societies, and above all through the National Safety Council.

It is worth while to point out that campus safety committees may use available publications covering standard practice to serve as a basis for training, inspection and recommendations for new equipment and buildings.

In connection with standards for safety in buildings, data are available on stairs and ramps, exits, lighting, ventilation and fire protection. Injuries from falls are common. Stairs and slippery floors are bad offenders. Fire hazards with greater potential hazards must be carefully watched.

Traffic on the campus is no differently regulated than in any other situation except that staff and particularly student drivers are subject to considerably more control than may be applied to the public.

Standard safe practices for mechanical, electrical, and power transmission equipment can be, but seldom are used in mechanical and electrical laboratories. There seems to be a feeling that the experimental nature of work done in laboratories justifies relaxation of safety requirements accepted in industry. Personal experience points to both the frequency and severity of accidents in these laboratories.

Even in a cursory discussion of safe practice standards it is important to make specific mention of eye protection. It is increasingly common to see industry require one hundred per cent use of goggles in situations no more dangerous than those faced in campus laboratories. Considerations of cost and absence of financial liability in case of student accident has caused slow acceptance of such an advanced program in universities. A goggle program may reasonably start on specific operations, generally recognized as hazardous and extend as rapidly as possible to all laboratory and shop work.

Partial eye protection is generally started with university owned equipment. Very welcome results can be obtained by a pressure program to persuade students to purchase personal goggles. The habit of eye protection, once formed, carries over to industry in a realization that a man in a shop without goggles is only partially dressed.

Conclusion

Some one said that the core of a successful safety program hinges on the influence of a fanatical few who view their environment with a perpetual safety skepticism. Their effectiveness is crippled or crystallized by the attitude of their superior officers. They can best accomplish their objectives by a thorough, widely spread organization, concentrating in a central safety committee the responsibility to advise, inspect, and educate together with a functional authority clearly defined by the scope of their assignment. A sound working formula may be derived from the recorded experience in approved safe practice codes that are readily available and definitely applicable to university situations. It appears that the safety job in the technical university is not essentially different from that encountered in non-academic surroundings. Just how big it will be cannot be evaluated previous to the collection and analysis of student and staff accidents.

Many of the recommendations thus far discussed may be varied to suit conditions. One additional item is of primary importance. A safety program, new or old, cannot do without, nor duplicate elsewhere, the support and guidance that are available from the

National Safety Council. Teaching material, publicity posters, statistical data, advice as to safety standards and safety programs are readily obtained by members of the organization.

Within the last few months the National Safety Council has published a booklet entitled "Student and Employee Safety in Colleges and Universities." The booklet presents a complete safety program with bibliography and other specific data. It can be recommended without reservation as a working text for anyone who wishes to inaugurate and operate a safety program.

To summarize, a team made up of a safety group from staff and students coöperating with the National Safety Council contains all of the essential elements of a program to reduce accidents on the campus and to provide a training in safety that will be permanently valuable.

THE FUNCTION OF BIOGRAPHY IN ENGINEERING EDUCATION

By THOMAS J. HIGGINS

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Man is an animal that thinks. To be a first-rate human being, a man must be both a first-rate animal and a first-rate thinker. . . .

ALDOUS HUXLEY

Perhaps that is why we have so few first-rate human beings.

RICHARD KLYBER

It is an evident truth that the average individual cannot write with ease, speak with facility, or read with skill. It is maintained by some that it would be difficult to find an exercise he more abhors than that of thinking. Still others hold that his life is function; his relaxation regimented and intellectually sterile; that conscientiously and intently he avoids the deliberate exercise of those special faculties, abilities, and mental skills that distinguish him from other animate objects. This is a bitter indictment. One hesitates to accept it in full. Yet, the stadia gates at major sporting events are seldom unjammed as the hour approaches, while one has still to see a queue before a library, to hear broadcast a master's chess tourney, to learn that the philharmonic holds sway as the nation's favorite program. In truth, rational consideration of these and kindred phenomena can well lead the reflective observer to place some credence in the aforementioned condemnation.

If so, the university student, being of the same genus and species, is guilty of like slackness of intellect and mental inertia. His offense is mitigated in that, willingly or not, the satisfactory discharge of the daily scholastic allotment requires of him considerable reading and some direct thought. One has, however, but to compare the number of students, the facilities of the fieldhouse, and the number of library chairs to deduce that literary pursuit beyond the textbook is scarcely a popular pastime, and with many scholars (if they may be so dignified) ranks after mountain climbing and before deep-sea fishing in popularity and frequency of participation.

Such gross neglect of an activity, so fruitful, so utterly indispensable to intellectual maturation, is centered, one feels, in the prevalent—one is even tempted to say prevailing—belief that read-

ing, other than under duress, is a prerogative of old age or physical infirmity, an addiction of the eccentrically inclined, an inescapable affliction of one's youth, or the queer and unhappy bent of misanthrope and your pallid spectacled creature generically, picturesquely, and contemptuously termed "bookworm," "grind," or "cant." That intense pleasure, excitement, and actual adventure can be gained from pages of print transcends many an imagination.

Now, despite the most fervent wish to the contrary, there is little specific reason to expect the average student of science or engineering to differ markedly from his fellow as concerns a *spontaneous* interest in reading verse, drama, literary criticism, analyses of the fine arts, recounts of bygone cultures, critiques on economic discipline, or many another of that multitude comprising the literature of the humanistic and social studies; nor, for the most part, is it to be dreamed that pedagogical pressure alone will arouse other than a tepid and temporary interest. These and the foregoing are sweeping remarks; they and the thesis implied will not escape criticism. Some will say—here is unbuttressed and ill-founded dogmatism; some will jibe—here is facetious pretense. Be that as it may, these tenets are grounded on firm convictions; nor is here the place to advance their genesis or to defend their rightness. It is maintained that a deep, a genuine, and an abiding love for a Muse is inborn, is innate; that it cannot be engendered by force, by exhortation, or by wishful thinking. To meet with a love at once spontaneous, ardent, full-flamed, and unquenchable is rare. In the hearts of most there is but a feeble flame; a flame, moreover, which requires a bellows if it is to flare even briefly. We teachers are such bellows. But even as the stoutest blast cannot fan into flame a pile without spark, so is the best of teaching certain to failure when that vital essence, a *natural interest,* is absent.

The summed function of teaching is to seek out, to recognize, and to arouse these latent ardors; once activated, to protect, to encourage, and to enhance them; and, finally, to wisely guide them, to make certain that effort is shunted into channels which are of *inherent* interest. To achieve these ends the zealous teacher will search out and utilize all means available to him. One such means, a useful tool in the hands of a skillful teacher, is the motivation inherent in the student's basic traits of character. Not the least of these traits is curiosity. Where a form of knowledge, the appeal of which is to the intellect, usually meets with a cold reception, a form that appeals to curiosity often receives a cordial reception. If possessed of educational worth such forms are valuable complements to formal instruction. An example of such is biography.

In biography one has a limited province of literary endeavor in which gentle coercion often arouses a lasting interest. . . . Why? Because biography panders to one of the deep-rooted instincts of man, his natural inquisitiveness; manifest in the thoughtless as an insatiable desire to acquaint themselves with the more rakish and more sordid affairs of his fellows, in the thoughtful as an urge to make known to themselves the every detail and method of an intellectual achievement. And surely, if there is one trait an engineer or man of science ought possess it is this latter kind of curiosity. And to sit, day by day, for four years acquiring new, strange, fascinating, and divers knowledge, and not to experience a desire to know of those who invented, developed, and perfected these techniques and theories, of why and how they did so, of their feelings, failings, foibles, and fiber is to demonstrate an unparalleled lack of it.

It is indeed true that to know Newton wrote the "Principia" in approximately eighteen months of ceaseless labor will not aid the student to grasp Newton's calculus more readily; nor is to know that Newton possessed his full complement of teeth but one until his death at 85 any great advantage in mastering his binomial theorem. What possession of this and kindred knowledge will do, though, is to make the study of these topics more interesting and more vital, to clothe them in whimsy and charm, to embed stark formulae and sterile procedure in a matrix of interesting association and fact, to soften harsh outline and to serve as sweetening and palliative.

For example! The Pythagorean theorem is stock-in-trade of every student. Who knew the perpetrator was mountebank, heretic, and mystic? Descriptive geometry is dull you say! Who knew the inventor, Monge, was soldier, savant, and statesman; that for years his invention was a prized and jealously-guarded military secret of the French army? And the caprice, the idiosyncracy, the varied expression of genius! Who knew that Helmholtz detested rutabaga, while Bernoulli was passionately fond of nuts; that Euler fathered a brood of thirteen, while Sylvester's bride and offspring were mathematics; that Maxwell wrote verse, Poincare ontology, and Franklin homolies; that at ten Sir William Rowan Hamilton knew a half-score of languages, and at fourteen wrote verse in Persian for an Oriental ambassador; that Kelvin was an enthusiastic yachtsman, Rumford an inveterate adventurer, and Rankine a zealous floriculturist? Who will deny that such trivia lend enchantment to genius, embellish recital of its accomplishment, and render assimilation of this latter less difficult.

But stay! The acquisition of such tidbits, appetizing though they be, is but a tithe of what is to be gained. The reading of

scientific and industrial biography cannot be interpreted functionally as merely a means of acquiring *hors d'oeuvres,* of obtaining morsels for titillating palates in preparation for the technical courses of the curriculum. Biography plays a dual role: it provides not only titivation but background, substance even as spume.

Engineering, unlike the dragon-toothed soldiers, sprang not full-fledged into a waiting world. It grew. Its development, at first slow and hesitant, at times stagnant for centuries, was accelerated through rapid increase in the cohorts of workers toiling in the numerous vineyards of natural philosophy. Yet, despite the horde that have labored, or now do so, the whole of engineering practice is predicated upon a few fundamental and invariable principles. Usually each was the discovery of a single man, of an individual who in mental stature towered, a veritable Colossus of Rhodes, over the majority of his contemporaries. Many were influential educators, scholars of note, or public servants of distinction as well as men of science: Kelvin, Helmholtz, Goethe, William Hamilton, Laplace, Newton, and a legion more come readily to mind.

Kelvin and Helmholtz were contemporaries, lifelong friends, had curiously parallel lives. The former taught at Glasgow for more than fifty years; was a dominant figure in British physics for a half century; may well be termed the first great electrical engineer. The latter, in succession incumbent of professorial chairs at Koenigsberg, Bonn, Heidelberg, and Berlin, rector of the latter, first president of the Physico-Technical Institute, was the greatest German physicist of his day, one of the most versatile scientists of all time. By virtue of their academic positions, the students they trained, the educational commissions they headed, their scientific accomplishment and personal prestige they were able to exert a formidable influence on the course of university education in their respective countries. Their stamp on the fields of physical science and general technology is particularly heavy.

Goethe and Hamilton were men of multifarious virtuosity. There have been few who combined the talents of novelist, dramatist, poet, philosopher, and scientist as did Goethe; few who have rivaled Hamilton: a prolific versifier, a coiner of epigrams, an eloquent speaker, a wit of note, a *bon-vivant;* a professional astronomer, a great physicist, a superlative mathematician, a writer whose volumes are his enduring monument.

Even as Hamilton was hailed the Irish Newton, so Laplace has been termed the Newton of France. The antithesis of his illustrious namesake in character, they were yet akin in magnitude and quality of accomplishment. Nor was this latter confined to scientific endeavor alone. Laplace, a shrewd and supple politician, weathered the fall of monarchy, the storm and confusion of revolu-

tion, the eclipse of empire. All redounded to his advancement and benefit: he was an intimate of Napoleon, Minister of the Interior, Count of the Empire, the colors of numerous orders variegated his attire; the monarchy restored, he became a peer of France, the Marquis Pierre-Simon de la Laplace. Though it lacked this garish glitter, Newton's political career surpassed it in span and quality. Forsaking Cambridge in mid-life, he undertook the post of Warden of the Mint. Fulfilling his duties with diligence and competence, he was advanced to Master of the Mint, a post held until his death.

We see, then, that to familiarize one's self with the lives, the work, and the achievements of such men is simultaneously to familiarize one's self with the method and thought of genius; the scientific, philosophical, and cultural activity of their time; the economic, political, and social problems of their time. To read biography is to witness the conception of idea, the birth of actuality, the growth of application. To read is to learn; to learn is to know; to know is to think; to think is to live, not exist. And one who thinks need have no regret for the past, concern for the present, or fear of the future; for, "armored in knowledge, girded with intellect, mounted on confidence one can await with tranquility the onslaught of event."

The bibliography below comprises readily available, full-sized biographies, for the most part in English, of men and women who were conspicuous in engineering or the directly associated domains of mathematics and the physical sciences. Each is interesting, each informative, each of value; each concerned with one of extraordinary aptitude and of noteworthy achievement in his or her sphere of endeavor. Of these, some were the founders of vast new realms of science, the originators of domains of thought previously undreamed; others developed new techniques, new instruments, or new processes, were the creators of new industries; yet others nurtured these latter, made them the livelihood of countless thousands, advanced the frontiers of the wilderness.

Accordingly, a knowledge of these persons as individuals will contribute much towards increasing understanding, appreciation, and enjoyment of technical studies. A knowledge of the kind and scope of their personal contributions will, in no small measure, deepen one's historical background—if, indeed, not create it—widen his perspective, and reveal science to be a live, constantly developing organism of formidable pedigree and notable ancestry. A knowledge of their associates, friends, and collaborators and of an approximate chronology of their activities will aid one interested in some particular phase of science or engineering to perceive its rational development; to appreciate the coördinated effort necessary

to its successful formulation; to gauge the relative importance of individual contributions; to understand how these latter have been integrated into an orderly whole; to prize the resultant structure; to judge the merit of new suggestion.

> They that know the entire course of the development of science, will, as a matter of course, judge more freely and more correctly of the significance of any present scientific movement than they, who limited in their views to the age in which their own lives have been spent, contemplate merely the momentary trend that the course of intellectual events takes at the present moment.[1]

A noted historian[2] of science has characterized the motif of biography thus:

> . . . suppose we had to tell the history of a single man. How would we set about it? The main point of the story, I take it, would be to explain the development of his genius, the gradual accomplishment of his special mission.

An example of scientific biography written in precisely this vein, and one particularly illustrative of foregoing remark, is Leo Konigsberger's "Hermann von Helmholtz," available in abridged translation by F. A. Welby. The author's avowed purpose is to make intelligible to all readers the fruits of Helmholtz's diversified genius. And they are manifold: a skilled mathematician—his paper on the hydrodynamical equations of vortex motion is classical; a superlative physiologist and anatomist—discoverer of the mechanism of the accommodation of the eye for distance, the founder of modern physiological optics; the foremost German physicist of his time—propounder of the law of conservation of energy (in the sense that the sum-total of energy in the universe is invariable), co-author of the Young-Helmholtz theory of color vision, the first to declare that electricity consists of atoms; a philosopher in the best meaning of the word—his general philosophical and epistemological views, based on exact investigation, were, in many instances, the antithesis of those promulgated by Goethe and the Hegelian school; his discussion of the foundations of the Euclidean axioms were immediately recognized as a valuable contribution to the theory of the nature of space; a writer, compiler, and monographist of enduring worth—his "Tonempfindungen" and "Physiological Optics" are monumental reference works; linguist, musician, teacher, surgeon, educator, and inventor, he lavished an abundant treasure. The scope and variety of his interest are amply attested by numerous passages from his original papers which, throughout the text,

[1] Ernst Mach, "The Science of Mechanics," English translation (1893) by T. J. McCormack, p. 7.

[2] George Sarton, "The History of Science and the New Humanism," p. 21.

are used by Konigsberger to emphasize or clarify the discussion of particularly important topics. The considerable value of such to the serious student, to the earnest seeker after truth, to each of us who takes pride in the competent practice of our profession is superbly stated by Mach:[3]

> . . . Apart from the consideration that we cannot afford to neglect the great incentives that it is in our power to derive from the foremost intellects of all epochs, incentives which taken as a whole are more fruitful than [those] the greatest men of the present day are able to offer, *there is no grander, no more intellectually elevating spectacle than that of the utterances of the fundamental investigators in their gigantic power.* Possessed as yet of no methods, for these were first created by their labors, and are only rendered comprehensible to us by their performances, they grapple with and subjugate the object of their inquiry, and imprint upon it the forms of conceptual thought.

Of Helmholtz, as of every man of preëminent intellect whom we would emulate, there are certain things we seek to discover. What were his antecedents? Who were his teachers, his friends, his pupils? Can his intellectual superiority and extraordinary endowments be attributed to a fortuitous combination of genetic vagary, parental wisdom, competent tutors, and brilliant companions? or were they Heaven-sent, innate? What were the genesis, the nature, and the vitality of his ideas? How were they influenced by his social environment? how aided or retarded by the social concepts of his time? What debt does his work owe to the past? who were his collaborators in it? how has it influenced that of posterity? Have his accomplishments lived on, become an integral part of our heritage, inspired those who came after him?

And the man himself, what of him? What was the temper of his spirit, the quality of his character? Was he jealous, selfish, sarcastic, possessed of hasty temper, riven by spells of suspicious anxiety? or was there assembled in him that which is good in man? Did he work for his own aggrandizement or for the common good? What motivated him: lust for power, greed for riches, a love of fame; or a relentless dæmon, a fierce and never-slaked thirst for new knowledge, new achievement, and the betterment to follow in their wake? Was he religious, agnostic, or atheistic; did he believe in God, in man, or in himself? Was he a puritan, a libertine, a hedonist, or a sybarite; did he crave austerity, lust, pleasure, or luxury? How was he judged by those who knew him? what was the verdict of those who came after him?

If these and questions of like import are fully answered, if the ramifications and implication suggested by them are exhaustively

[3] Loc. cit. (The italics and brackets are mine).

treated—and in *Hermann von Helmholtz,* as in many of the others, they are—we have bared for inspection the articulated armature of rigorous deduction, have stripped for study the mind and temperament of genius. Thus prepared, a thorough examination with an eye to determining the method and makeup of those who forged our industrial and scientific heritance can scarcely do other than to inspire us as we, in our turn, take up the task of addition; to encourage us, when in moments of dispair and doubt we tend to falter; to foster hardihood that will enable disappointment and toil, inevitable in our quest, to be endured with equanimity; to minimize the anxieties and fears aroused by the vicissitudes of a kaleidoscopic time; and finally, perhaps most needful of all, to stimulate a flagging faith in the fundamental goodness of all mankind and in the ultimate triumph of its idealism, its aspiration, and its spiritual and æsthetic content.

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A WORM'S EYE VIEW OF ELECTRICAL ENGINEERING EDUCATION

By GEORGE W. DYSON

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Much has been written on the subject of engineering education. In the journals of the learned societies, the successful industrialist presents his conception of engineering education, while in the same journals the engineering educator expands his ideas. Unfortunately, all too often the industrialist is far removed from the practical applications of education, while on the other hand, the educators are so close to the subject that, to use a trite expression, they cannot see the forest for the trees.

What is needed are opinions from the students who are being subjected to this educational process. What do they think of engineering education? True, in many cases, the students are too young or inexperienced to be able to evaluate the various subjects that make up a curriculum. But educators in fields other than engineering have found that out of the mouths of babes, genuine wisdom very often issues. Particularly valuable would be the comments of men who are working for their degrees in the evening divisions of such schools as New York University or the Polytechnic Institute of Brooklyn. During the day these men are wrestling with industrial problems; in the evening they become familiar with practical applications of the so-called educational process. Surely, they must have some opinions which would be valuable to those who are genuinely interested in the betterment of engineering education. It is, as a member of this group, that the writer presents his views.

Before any constructive criticism can be made of engineering education it must be recognized that the students in our engineering colleges today are carrying too heavy a load. While engineers assiduously study fatigue as it refers to metals, they give little or no consideration to fatigue as it refers to the brain. This perhaps accounts for the heavier load carried by engineering students as compared with that of the liberal arts students. This load must be lightened in order to give the engineering students time to think.

We are then confronted with two propositions; either we must accept the five or six year curriculum or we must drastically revise the present four year curriculum. *The Report of Committee on*

Aims and Scope of Engineering Curricula believes that it is possible to provide a satisfactory professional engineering curriculum in four undergraduate years. While admitting candidly that there are serious objections to the increase in number of years from four to five or six, these objections will have to be met. Universities like Columbia and Harvard whose endowments are sufficient to allow them to experiment have taken the initiative. If the educational history of the law, medicine, and theological professions is any criterion, all engineering schools will eventually fall into line.

While waiting for the five or six year plan to become universal, it behooves the upholders of the four year plan to examine their curriculum. How can it be improved? How can it approach—a four year curriculum cannot meet—the objectives of the scientific-technological studies and humanistic-social studies as outlined in the above report.

The four year curriculum can be improved by adapting it more to the needs of the *average* engineering student. This, in turn, requires that educators and students alike practice a little intellectual honesty. They must recognize that the *average* engineering graduate is not going to do anything outstanding. He will plod along in a routine job and his progress will depend far more upon his personality than it will upon his knowledge of calculus.

A careful examination of a curriculum will disclose a number of courses whose value to the average student is negligible. In the interests of efficiency—the God every engineer worships—they should be relegated to the graduate school or, at the best, offered as optional courses for the brilliant student.

As a concrete example of required subjects not suited to the needs of the *average* engineering graduate consider the subject of transmission lines. Every engineering college in good standing considers itself in duty bound to give a course in transmission lines. The neophytes struggle with hyperbolic functions, derive long winded expressions for sending and receiving currents and, in general, are made miserable with mathematical gymnastics. Why? Well, no one seems to know. Even the instructor who gives the course admits that only an infinitesimal percentage of the students will ever indulge in any calculations on transmission lines. When further pressed, he will fall back on the old expression "it trains the mind." Educational psychologists, however, have determined that the theory of "Transfer of Training" is no longer tenable.

The only courses which should be required of a student in the undergraduate department are the ones which teach those fundamentals upon which all engineering rests.

Mathematics? Certainly, every one will agree that an engineer should be well grounded in mathematics. But, the question which now arises is: Are engineers well grounded in mathematics? True —they are required to pass examinations in mathematical subjects up to, and including, differential and integral calculus. But, with the subject load they are carrying, do the students have the time really to absorb the material that is thrown at them? It is to be doubted! Rather, pressed by time, the average student obtains a superficial knowledge which enables him to get by but which, at no time, gives him a mastery of mathematics. More time is needed to drill the students until the subject becomes part of their subconscious selves. In other words, to borrow a term from the educational psychologists the subjects should be over-learned.

Next to mathematics, the most important tools in an engineer's intellectual kit are physics and chemistry. Engineering educators have played lip service to those two subjects for generations. But, with the over-loaded curriculum, the student does not have the time to absorb these all important subjects. Rather he must be satisfied with a sketchy knowledge of physics and chemistry so that he can rush on and chase harmonics around a transmission system.

Now to round out the technical side of an engineer's training, what subjects are necessary? Very few! A course in thermodynamics, a course in strength of materials, a course in metallurgy, a thorough course in fundamentals of electrical engineering and a course in mechanical drawing. The latter course should be given for no other reason than it will eliminate through sheer boredom, a great many incompetents from the field of engineering.

It will be noted that courses in D.C. machines, A.C. machines with their concurrent lab courses have been omitted. It will also be noted that no mention has been made of courses in the communications group. There is a very good reason for these omissions. It is that no student should be required to take both power and communications subjects. Either group is a separate study in itself and should be regarded as such. Of course, to the engineering educator this is sheer heresy. He insists, that the man who is interested in power work subject himself to courses in communications. Conversely, the communication man must suffer in silence while he is being bored to death in a class in electric lighting. Educational efficiency would dictate that these subjects be placed in elective groupings. But, no, the educators insist that all electrical engineers conform to the same standards.

As a result, on the surface at least, all electrical engineers have a basic knowledge of both communications and power. Actually what happens is that the men who are interested in power work make an effort to master the subject while the communications men blandly

crib their way through. Conversely, the communications men digest their filters with great glee while the power men maintain a respectful degree of silence.

A sound education policy would dictate that a study be made of those topics in electrical engineering which are basic and essential. Around these topics build a basic course which all students have to take. The next logical step would then be to round out the technical portion of the curriculum with two groups of electives. One group would include subjects of primary interest to the power students while the other group of subjects would answer the needs of the men interested in communications.

One school of educators argues that a student does not know, in his undergraduate years, whether he will be a radio engineer or a designer of turbo-generators, hence he cannot intelligently select his elective subjects. Perhaps! Under the present system, the *average* engineering student can obtain only a superficial knowledge of the fundamentals and a nodding acquaintance with the specialties. It would seem far more efficient educationally to give the average engineering student a thorough knowledge of the fundamentals and an introduction to one specialty. A thorough knowledge of the fundamentals will permit a young engineer to handle any type of job which may come his way.

Cultural Subjects

It is not to be denied that the social responsibilities of the engineer are increasing. It is therefore, pertinent to examine the cultural background they receive in engineering schools. Of course, there are many definitions of culture or perhaps it is better to say that there are many opinions as to what constitutes culture. One opinion is that only those who possess a reading knowledge of Latin and Greek are cultured. Another opinion is that advanced by William O. Hotchkiss, President of Rensselaer Polytechnic Institute, who states, "My definition would credit a man with the possession of culture when he sees in their proper perspective the factors of any problems he is considering; when he has a sense of relative values of things and of men; when he is able to separate the true from the false; when, in short, he is possessed of those qualities that make a well balanced mind."

A moment's reflection will convince anyone that a person can be cultured without a reading knowledge of Latin and Greek. Another moment's reflection will convince one that a person can meet every one of Dr. Hotchkiss's qualifications and still be absolutely devoid of culture.

Culture implies not only a well balanced mind, but also a well rounded mind. A cultured mind is constantly reaching out and exploring the realm of history, biography, literature, art and music. A cultured mind in addition to obtaining that knowledge which is essential to making a living is constantly trying to attain that knowledge which makes life worth living. It is not, however, as John C. Parker has so well stated, "a matter of hanging some academic trappings on the outside of a boor or of training his tongue trippingly to repeat phrases or to refer to events in history which have left him as a man quite unmoved." ("This Culture," John C. Parker, *Electrical Engineering*, June, 1940.)

Engineering students have always looked upon the cultural courses as a waste of valuable time. The great majority accept patiently the doses of English, history and economics which are ladled out to them. Occasionally they may read an outline book in history or they may toss off a theme, "A Description of a Thermometer." But, except in the case of isolated individuals, they make no serious effort to master the courses. Imagine the storm that would break over the head of an instructor in English who required the same amount of work from his students as, for example, does the instructor in calculus. Yet, in the last analysis, which is likely to be the more useful tool in everyday life—English or calculus?

This regrettable attitude of the engineering student towards the cultural subjects stems from two sources. First, the failure to realize the practical importance to an engineer of having a good cultural background. Second, the failure of the English and history departments to demonstrate that value.

As has been stated, the engineering student cannot see any practical value in the cultural courses. It is not until he has achieved a measure of success and is compelled to meet successful people in other lines that he suddenly realizes his own shortcomings. The materially successful engineer then pathetically joins a public speaking class in the naïve belief that he can learn to speak interestingly in ten easy lessons. Failing in this, he turns to the latest compendium of world's best literature and proceeds to absorb the culture of the ages. However, a mental diet of tabloids, magazines which feature pre-digests of other magazine articles and the picture magazines have so weakened his mental digestion that he is incapable of understanding a serious work on history, biography or sociology. The only way he can then save his self-respect is to belittle. This he does with enthusiasm and whenever a book appears which does not beat the drums of patriotism he snorts. "Those damned Reds. Now if engineers only took an interest in. . . ."

Of course the average engineer protests that he has not the time to read. He is so busy that he has to have his material pre-digested, condensed, visual or served up as mental pablum. Now we might grant there is some measure of truth in these arguments were it not for the fact that the really big men in the profession find time to read. For example, no one would deny that Dugald C. Jackson occupies a very high place among electrical engineers. Yet, Dr. Jackson's articles on the backgrounds of civilization printed in *Mechanical Engineering* exhibit a life time of general reading. Karapetoff can be used as another example—a prominent electrical engineer, an accomplished musician, a lecturer on general topics and a composer of excellent verse. Vannevar Bush and Willis R. Whitney can also be used as examples of well rounded engineers—men whose writings exhibit the fact that they have had time to read.

Now the English and history departments of engineering schools cannot divorce themselves from the blame for this attitude. The members of these departments usually feel that their subjects are of minor importance and it is only necessary to insist upon the minimum amount of work. Classes in English and history become, then, breaks in the day's occupation known as the "snap-hour."

This defeatist attitude and I think that any instructor who views his subject as a minor subject is assuming a defeatist attitude, is transmitted to the student. If the instructor does not deem his subject important you may rest assured that the student will view it in exactly the same way. On the other hand, if an instructor firmly believes in the practical value of his subject he can transmit that belief to the majority of his students. The very least he can do is to make the students respect the course and, if necessary, deny degrees to those whose knowledge of English and history indicate that they desire to become mechanics rather than engineers. Further, in those schools that still insist upon that anachronism of education—the undergraduate thesis—the English department should insist upon one of their members approving the thesis as to its English content.

There still remains one big step to be taken. It is the abolishment of special classes for engineers in the cultural subjects. Of course, in the polytechnic institutes and colleges devoted exclusively to engineering this is not possible. But in the universities, little excuse can be offered for grouping engineering students together and subjecting them to an emasculated course entitled, *An Intensive Course in Engineering English.*

In such classes, the student is thrown in with his brother embryo engineers. Assuming for the moment that the instruction is all that can be desired, are the results satisfactory? I doubt it! All the students are thinking along the same lines. Let's get this

over with as quickly as possible. There is no class of interests, no divergence of viewpoints that stimulate interest and make a class worth while. The instructor, himself, cannot escape this deadening influence. He knows that he is teaching engineering English to engineers. Why exert himself?

On the other hand, the throwing of the student engineer bodily into a class where he must, of necessity, match wits with student doctors, ministers, priests, lawyers, communists and what have you, broadens his intellectual outlook. He has to conform to the standards of his associates or fail the course. The instructor does not teach engineering English, but tries to give his charges the benefits of the accumulated culture of the ages.

Teachers

It is no longer considered good form to refer to the gentlemen whose duty it is to impart knowledge to engineering students as teachers. Perhaps that is the reason why the teaching in engineering colleges is, on the average, deplorably poor—the staff is so busy learning to be instructors that they have little or no time to learn the homely art of teaching. It has been said and I think with a measure of truth that the grade of teaching decreases in geometrical progression as one advances from kindergarten to a Ph.D.

An instructor in an engineering school is selected, it would seem, on the basis of the number of degrees he has appended to his name, the books he has written, the research problems he has investigated or the honorary fraternities of which he is a member. In order to secure a job teaching, rather, I mean instructing, a class in college algebra or elements of electrical engineering a young man should have written a highly obscure thesis—which nobody has ever read—on some very vague aspect of electrical engineering. It would be considered sheer heresy to expect this brilliant young research engineer to have taken a course in educational psychology or a course in methods of teaching.

In case anyone doubts the statement that teaching in engineering college is "deplorably poor" let him examine the professors under whom he studied in college. Strip them of their professional reputation, remove the aura of sanctity that surrounds any one who has written a book, and let them stand naked to be judged only on their ability to teach. Then attempt to name five professors who deserved the distinction of being called teachers.

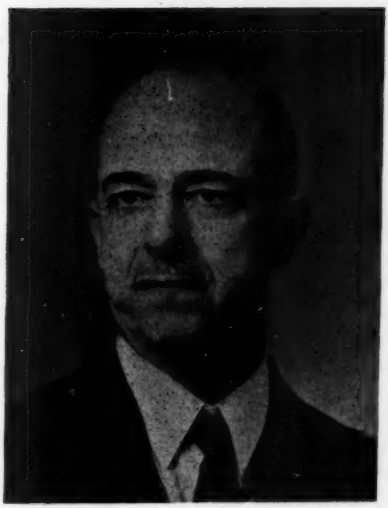
Of course, the stock answer of those who defend the present grade of teaching is that in college a student does not need to be led around by the hand. Teaching does not imply "leading by the

hand." It implies knowledge of one's subject, the ability to put the subject across, and the knack of stimulating young minds to intensive work. But, it does not imply, as so many engineering instructors seem to think, that all the work shall be done by the young minds.

No improvement will come until the engineering colleges recognize that eminence in engineering or potential ability along research lines bear no direct relationship to teaching ability. Once this fact is recognized and instructors are engaged upon the basis of their ability to teach then, and then only, will any noticeable improvement in the grade of instruction be perceived.

Anyone who has been subjected to an engineering education has his own conception as to its failures and accomplishments. However, it is the writer's belief that any distinct improvements that are made will have to be along the lines outlined in the paper, *i.e.*

1. Drastic revision of curriculum
   - (*a*) Stress on fundamentals and basic subjects
   - (*b*) Establishment of major and minor fields of study
2. An awakening in engineering students of the need for a cultural background
3. More teachers and fewer instructors on the faculties of the engineering schools.



THE SOCIETY FOR THE PROMOTION OF ENGINEERING EDUCATION

announces with deep regret

the sudden death on September 4, 1941

of Vice President

FRANK LEWIS EIDMANN

Member of the Council, 1931–34

Professor of Mechanical Engineering
Columbia University, New York City

WHEN SHOULD AN ENGINEER OBTAIN A GENERAL EDUCATION?

By ALFRED H. WHITE, *President*

Our young engineers have little conception of the improvement in working conditions since their fathers started to work. Only twenty-five years ago, I worked in a mill which operated with twelve-hour shifts seven days in the week, with the men changing from the day to the night shift on alternate weeks. Those who came off the day shift on Saturday night could look forward to a full night's rest and one free day before they started on the night shift. The following week they worked not only Saturday night but all day Sunday as well, a straight twenty-four hour shift, to pay for their free day of a week before. This mill was not unusual in its working schedule. The steel industry did not change to the eight-hour shift until several years later. Engineers in the drafting rooms, laboratories and offices did not work as long hours as those in the operating divisions but the ten-hour day and six-day week was the general rule here. Whatever an engineer did, his work was so fatiguing that he had little energy for any constructive program for utilizing his few leisure hours.

The discoveries and developments of the scientist and the engineer have liberated the worker and incidentally the engineer himself from the serfdom of drudgery. The young engineer, like the laboring man, now works only forty-four or perhaps only forty hours a week. After adequate time for sleep and recreation, there still remains a substantial residue of hours which should be devoted to self-improvement.

The engineer has been reproached by a past generation for his lack of culture, for his failure to assume adequate leadership in public affairs, and for his ineffectiveness as a speaker and a writer. The remedy prescribed has frequently been a two-year general college course as a precedent to the engineering school.

Culture defies exact definition, but it is certain that it cannot be imparted by feeding a student a prescribed intellectual diet. It demands not only breadth of knowledge but also thoughtful consideration of the implications of this knowledge and its application to our way of life. Nearly fifty years ago the story was told of the Chicago millionaire who was reproached with the lack of cul-

ture of his city. His reply was, "No, Chicago hasn't gotten around to culture yet but when she does, she'll make the old gal hum." The millionaire spoke truly when he implied that a young and growing organism is chiefly interested in the material things which promote its immediate welfare. The mysterious thing called culture can only come with maturity.

A generation ago if the young engineer was to acquire a general education, he had to get it before he started work, because for the next twenty-five years he would have to devote all his energy to his job. If the older engineer did not assume the expected leadership in public affairs, it was because of the strenuous demands of his professional work.

This emancipation of the adult from exhausting, deadly toil cannot but affect our educational systems. Adult education has already become a great movement and it is incumbent upon us to examine our educational procedure and see if it is fitted to carry this new superstructure. The adult and the child alike do well in those studies which interest them, and they are interested in those studies which seem of immediate importance to them. The college freshman who wants to be an engineer digs into his mathematics because he knows that a knowledge of that subject is essential. He is often impatient of history and literature because they do not seem important for his future career. He will work at English if proficiency in that subject can be shown to be important to his professional success.

Our undergraduate engineering programs give the student some work which he recognizes as professional even in his freshman year. If he likes it, well and good. If he does not, he can change his program at the end of a year satisfied that he belongs somewhere else and ready to make a serious try at his next interest. When he graduates he has a working knowledge of English and the principles of economics in addition to his scientific and technical education. Most important is his training in observation, experimentation, and deduction. A young man with this equipment and with some leisure can extend his knowledge as he sees fit.

The Engineers' Council for Professional Development has prepared lists of books which will be helpful. Evening classes are numerous in the large cities. There are not so many organized facilities for self-improvement in small cities, but even in small towns there may be found a group of men and women interested in working together for the good of themselves and the community. Problems of government, labor relations, taxation, health and public schools appeal to the young engineer as a member of the com-

munity. The news of the world prompts a study of historical backgrounds, the distribution of racial groups, and the problems which arise from unequal distribution of natural resources among the various nations. Music, art and literature attract a group whose interests are not satisfied by the movie and the juke box. If the young engineer is wise he will associate himself with these forward-looking groups and, by study and reflection acquire a general education and, in time, culture.

The Board of Regents of the **University of Arizona** at the meeting held on June 28, 1941, decided to establish an Engineering Experiment Station in connection with the University, and appointed members of the faculties of the Colleges of Engineering and of Mines to staff positions; G. M. Butler, Director; E. S. Borgquist, Sanitary Engineer; T. G. Chapman, Process Metallurgist; J. C. Clark, Electrical Engineer; E. H. Crabtree, Associate Mineral Dressing Engineer; J. B. Cunningham, Pyro-metallurgist; W. C. Currie, Assistant Mechanical Engineer; H. M. Fitch, Assistant Civil Engineer; H. A. Jimerson, Assistant Mechanical Engineer; F. C. Kelton, Civil Engineer; N. L. Martinson, Assistant Civil Engineer; E. J. Nyhend, Associate Mining Engineer; J. C. Park, Highway Engineer; O. H. Polk, Associate Electrical Engineer; A. J. Thompson, Assistant Physical Metallurgist; N. L. Thornburg, Mechanical Engineer; P. M. Thornburg, Associate Mechanical Engineer.

Research on a number of problems of particular interest to people in the Southwest will be started soon after the University opens in September.

ENGINEERING, SCIENCE, AND MANAGEMENT DEFENSE TRAINING

ANSWERS TO QUESTIONS ISSUED AUGUST, 1941

(Subject to Revision)

The "Answers to Questions" contained herein are issued as a guide to degree-granting colleges and universities participating or considering participation in the program of Engineering, Science, and Management Defense Training (hereinafter referred to as E. S. M. D. T.), organized under the Labor-Federal Security Appropriation Act, 1942 (Public No. 146, 77th Congress, 1st Session, approved July 1, 1941), and administered by the United States Office of Education. In relation to the E. S. M. D. T. program, these "Answers to Questions" supersede "Answers to Questions Pertaining to Engineering Defense Training" (E. D. T.—Misc. 1) issued in November 1940, which apply only to the program of engineering training organized under the First Supplemental Civil Functions Appropriation Act, 1941 (Public No. 812, 76th Congress, 3d Session). The two programs, E. S. M. D. T. and E. D. T., are entirely distinct and separate as they are organized under different Acts of Congress.

All E. S. M. D. T. forms, miscellaneous releases, and other documents referred to herein can be secured from the Director of Engineering, Science, and Management Defense Training, U. S. Office of Education, Washington, D. C.

I. QUESTIONS

A. General

1. Under what law is the program organized?
2. What is the objective of the program?
3. How is the program administered?
4. What is meant by "Regional Coördination"?
5. What is the "approved plan" of an institution?
6. What institutions are eligible to participate in the program?
7. Under what conditions may facilities of non-eligible institutions be utilized?
8. How are training needs determined?
9. What respective sums are available for courses for engineers, chemists, physicists, and production supervisors?
10. When will the program terminate?

B. Courses

11. What kinds of courses may be offered?
12. What is meant by "short" courses?
13. What is meant by "courses of college grade"?
14. May college credit be given for E. S. M. D. T. courses?
15. How is the course content designed?

C. Trainees

16. What means are to be used to acquaint prospective trainees with the availability of these courses?
17. How does a person apply for admission to a course?
18. How are trainees selected?
19. Who may be admitted to courses?
20. May courses be restricted to certain groups?
21. Will discrimination because of sex, race, creed, color, or national origin be permitted?
22. What number of trainees may be admitted to a course?
23. What personal expenses do E. S. M. D. T. trainees incur?
24. Will trainees be deferred from Selective Service?
25. What aid will be given in placement?

D. Educational Administration

26. What institutions are expected to offer courses?
27. How is the program administered within the institution?
28. What standards apply in the selection of personnel?
29. How is compensation of employees to be determined?
30. May Federal employees receive compensation from E. S. M. D. T. funds?
31. What limitations are placed on the total load of employees?
32. What benefits are employees entitled to receive?

E. Proposals

33. How may an institution propose courses and receive a grant of funds?
34. Is a separate final proposal required for each preliminary proposal?
35. How may changes in a final proposal be requested?
36. What is meant by "cost of courses"?
37. Will an institution be reimbursed for the cost of courses discontinued or modified at the request of the Director?
38. How are costs of courses to be classified?
39. What is meant by "organization expenses"?

F. Fiscal Administration

40. What limitations are placed on expenditures for equipment and space?
41. Who holds title to equipment purchased?
42. How are funds to be expended?
43. Who is responsible for loss or misappropriation of funds?
44. What are the requirements for keeping and auditing accounts?

G. Records and Reports

45. What reports are required of institutions participating in the program?
46. What records of trainees should be kept by the institution?
47. Should certificates be given to trainees?

II. Answers

A. General

1. *Under what law is the program organized?*

   (*a*) Title II, subheading "Education and Training, Defense Workers (National Defense)" of the Labor-Federal Security Appropriation Act, 1942 (Public No. 146, 77th Congress, 1st Session, approved July 1, 1941, hereinafter referred to as the Act), authorizes the E. S. M. D. T. program. (See appendix.)

   (*b*) Section 704 of Title VII of the same Act has been held to apply to every person who is paid, in whole or in part, from funds made available to colleges and universities for participation in E. S. M. D. T. (See appendix.)

   (*c*) The "Regulations Governing the Education and Training of Defense Workers" promulgated by the United States Commissioner of Education and signed by the President of the United States, pursuant to the Act named above includes general regulations governing the organization and conduct of the E. S. M. D. T. program.

2. *What is the objective of the program?*

   The objective of the program is to provide short courses of college grade which are "designed to meet the shortage of engineers, chemists, physicists, and production supervisors in fields essential to the national defense." It is not a general college program, but training for a specific activity. The E. S. M. D. T. program should not seriously disturb regular curricula of the institutions, since persons fully trained in such curricula will continue to be needed in large numbers.

3. *How is the program administered?*

   The primary responsibility for the administration of E. S. M. D. T. rests with the United States Commissioner of Education. He performs his functions under the direction and supervision of the Federal Security Administrator. The Commissioner has designated a Director of Engineering, Science, and Management Defense Training, to whom he has delegated certain powers, duties, and functions, including the chief responsibility for carrying out the E. S. M. D. T. program. A small administrative staff assists the Director.

   Advisory to the Commissioner and the Director in the formulation of policies and procedures and in the general coördination of the program is a National Advisory Committee of 14 mem-

bers representing the several professions for which training is provided in the Act, and serving without compensation.

Twenty-two regional advisers assist in coördinating defense training in the institutions with the defense needs of Government and industry, to the extent and in the manner prescribed by the Director. Each regional adviser is a regular staff member of one of the institutions within his region and serves the E. S. M. D. T. program without compensation.

An important function of the regional adviser is to serve as chairman of a regional committee, composed of representatives of the participating institutions within his region, as well as representatives of other agencies vitally concerned with the E. S. M. D. T. program, as, for example, the public employment service, Civil Service Commission, state boards for vocational education, Training within Industry and Regional Labor Supply Committees of the Office of Production Management, and state or local defense committees. (See question 4.) For administration of the E. S. M. D. T. program within the institution, see question 27.

4. *What is meant by "regional coördination"?*

"Regional coördination," as provided for in the Act, means the coördination of the E. S. M. D. T. programs of the several institutions with each other and with the defense needs of Government and industry. It is the principal concern of the regional advisers and regional committees and is an important function of the institutional representatives and of the National Advisory Committee. (See questions 3 and 27.)

5. *What is the "approved plan" of an institution?*

The "approved plan" referred to in subdivision (3) of the Act is the "Plan for Short Engineering, Science, and Management Courses of College Grade," E. S. M. D. T.—Form 3, after it has been executed and submitted by the institution and approved by the Director, together with all preliminary and final proposals for courses and proposals for regional coördination submitted by the institution and approved by the Director. Federal funds under the Act cannot be transmitted to an institution until its plan has been approved. The approved plan is subject to revision from time to time by the approval of additional proposals, and is formulated with a view to the most effective utilization of institutional facilities in carrying out the E. S. M. D. T. program. (See question 33.)

The approved plan of an institution for the E. S. M. D. T. program is entirely distinct from the approved plan for the E. D. T. program conducted under Public No. 812. A separate plan must be submitted and approved for the E. S. M. D. T. program, and separate accounts, records, and reports are required. However, Section 602 of the Regulations (see question 1) provides for continued operation of the training program under plans pursuant to Public No. 812 until new plans pursuant to the Act can be submitted and approved.

6. *What institutions are eligible to participate in the program?*

Only degree-granting colleges and universities whose educational property is exempt from taxation by virtue of the provisions of the special or general law under which they are organized and operate, and public degree-granting educational institutions are eligible to receive funds under subdivision (3) of the Act. "Degree-granting" has been interpreted to mean that the institution, in recognition of satisfactory completion of a curriculum of four years or longer beyond high school graduation, during the academic year 1940–41, granted degrees with a major leading to a professional career in engineering, chemistry, physics, or production supervision. (See question 26.)

7. *Under what conditions may facilities of non-eligible institutions be utilized?*

An eligible institution may provide in its proposals for the utilization of facilities of other public or private agencies and institutions, if these facilities are more suitable or economical than other available facilities. In such event the eligible institution assumes full responsibility for the scope, content, and standards of instruction of the courses so conducted, and for the actual direction and control of all E. S. M. D. T. activities in connection therewith, in all important substantive and procedural aspects.

8. *How are training needs determined?*

Local and regional defense training needs should be explored and provided for to the greatest possible extent by the institutions through the institutional representatives and regional advisers. National training needs are explored by the staff in Washington and information pertaining thereto transmitted to the institutions. Final responsibility for deciding issues respecting the existing and anticipated needs for training rests with the E. S. M. D. T. Director.

9. *What respective sums are available for courses for engineers, chemists, physicists, and production supervisors?*

The total sum appropriated by Congress for E. S. M. T. D. is $17,500,000. In justification for the appropriation, as submitted to Congress, this sum was divided as follows:

(*a*) For training of engineers	$16,400,000
(*b*) For training of chemists	500,000
(*c*) For training of physicists	100,000
(*d*) For training of production supervisors.	500,000

Allocations of funds for courses will be kept as nearly as practicable within these amounts if consistent with defense needs. Assignment of courses to the four types will be on the basis of the fields in which it is expected that trainees will find employment. Thus, courses in chemistry, physics, and production supervision for persons employed or expected to be employed in engineering work will be considered as courses designed to meet the shortage of engineers. Only courses in production supervision for non-engineering personnel will be considered as courses designed to meet the shortage of production supervisors.

10. *When will the program terminate?*

Preliminary proposals must be approved and instruction in all courses must be begun not later than June 22, 1942. Instruction in E. S. M. D. T. courses must terminate not later than September 30, 1942. All E. S. M. D. T. activities of any institution must, however, be strictly within the contemplation of its plan as approved on or before June 30, 1942.

B. Courses

11. *What kinds of courses may be offered?*

Only short courses of college grade designed to meet the shortage of engineers, chemists, physicists, and production supervisors in fields essential to the national defense can be conducted under the E. S. M. D. T. program. The courses should be designed to train for a specific activity of *immediate* application. Two general kinds of such courses may be offered:

(*a*) "Part-time" courses for persons already employed either in defense or non-defense activities to give training for increased responsibility, improved technique, or new employment in fields essential to the national defense. Such courses may be given either on or off campus in the day or evening, and will ordinarily require about 6 to 12 hours a week in class and preparation.

(*b*) "Full-time" courses primarily directed toward new employment but available to persons already employed in defense activities who may be assigned by their employers to take the work. Such courses may be given either on or off campus, and will ordinarily require about 45 to 60 hours a week in class and preparation.

12. *What is meant by "short" courses?*

E. S. M. D. T. courses should, in general, be from 12 to 16 weeks in length. Part-time courses should ordinarily require a total of from 90 to 180 hours in class and preparation, and full-time courses from 600 to 800 hours. Much longer or much shorter courses should be proposed only to meet special conditions fully explained in the proposals.

13. *What is meant by "courses of college grade"?*

Defense training programs administered by the U. S. Office of Education are of two general kinds:

(1) Vocational courses of less than college grade administered through the State Boards for Vocational Education. Such courses cannot be included in the E. S. M. D. T. program.

(2) "Short courses of college grade," provided by degree-granting colleges and universities under direct administration of the U. S. Office of Education. "College grade" refers to the character and content of the course and not to an institution, and indicates an academic standard customarily required of college and university students in the same field. Only such college-grade courses can be given in the E. S. M. D. T. program. It is not necessary that they be identical with courses given to regular college students. Ordinarily they will be of a more intensive and applied character in order to give specific training for a particular job.

14. *May college credit be given for E. S. M. D. T. courses?*

Whether academic credit will be given by an institution for any E. S. M. D. T. courses is a matter for the institution to decide. (See question 19.) Attention is directed, however, to a resolution adopted by the Engineering Defense Training regional advisers at a meeting on June 27–28, 1941, reading as follows: "It is the sense of this meeting that this group recommend to coöperating institutions that no college credit be given for E. D. T. courses." The regional advisers also recommended that a resolution adopted by the Committee on Engineering

Schools of the Engineers' Council for Professional Development be brought to the attention of coöperating institutions. This resolution is quoted below:

"The wide variety of courses offered under the 'E. D. T.' program and the quality of instruction achieved lead inevitably to consideration of college credit. The Committee on Engineering Schools of the Engineers' Council for Professional Development is cognizant of the arguments advanced from the academic point of view for the granting of such credit. It recognizes, however, that the primary purpose of this instruction is specialized preparation for national defense.

"In view of potential interference with the primary objective by modification of courses to permit academic credit and in view of the specialized character of the instruction, the Committee recommends that, in general, credit be not given."

15. *How is the course content designed?*

It is the responsibility of the institution to prepare outlines for the E. S. M. D. T. courses it proposes to give. Course content should, when possible, be worked out with representatives of the industry or agency for which the training is to be given. Each course should be designed to meet a specific defense training need. A limited number of suggested course outlines in fields in which there is considerable training need on a national scale are prepared by the E. S. M. D. T. staff and sent to participating institutions. Final approval of the content of an E. S. M. D. T. course rests with the Director. The procedure for proposing courses is outlined in the answer to question 33.

C. Trainees

16. *What means are to be used to acquaint prospective trainees with the availability of these courses?*

Widespread announcements should be made by the institution through newspapers, technical publications, posters, bulletins, and radio stations. In addition, institutions may wish to circularize their former students. Publicity may advantageously be spread through local industries which would benefit from the training. Close coöperation should be maintained with employment services and industrial executives.

17. *How does a person apply for admission to a course?*

Application is made by the prospective trainee directly to the institution of his choice. If he is in doubt as to where a suitable course for him is available, he should address an inquiry to

the Director of Engineering, Science, and Management Defense Training, U. S. Office of Education, Washington, D. C.

18. *How are trainees selected?*

Each institution is responsible for the selection of persons to be admitted to its courses, subject to the provisions of its approved plan, including the prerequisites stated in its approved proposals. (See answers to questions 19, 20, and 21.)

19. *Who may be admitted to courses?*

Any person who is employable in a defense activity, immediately available for employment on completion of his training, and capable of performing academic work of college grade meets the general requirements for admission. High school graduation or equivalent education is a minimum essential for any E. S. M. D. T. course, while some courses may require several years of experience or of college training, or even a graduate degree.

There are no age or citizenship requirements except as they may be imposed for particular courses due to employment restrictions in certain industries. Admission to any course is subject to its specified prerequisites as noted in the answer to question 18. Only in special cases approved by the Director may anyone be admitted to an E. S. M. D. T. course while he is enrolled as a regular college student. Such approval will not be given except for senior or graduate students who are pursuing programs of study in engineering, chemistry, physics, or production supervision. In such instances the E. S. M. D. T. course must not be taken for college credit or as a substitute for a regular college course.

20. *May courses be restricted to certain groups?*

When necessary to protect military or trade secrets or otherwise to serve the best interests of national defense, enrollment in certain courses may be restricted to members of the armed forces or employees of a single industrial concern. Any such restriction should be justified in the proposal for the course or in a letter to the Director and must have his approval. In general, enrollment should not be restricted unduly, and restricted courses should be paralleled whenever possible by open courses of essentially the same course content.

21. *Will discrimination because of sex, race, creed, color, or national origin be permitted?*

The Act specifies that "No trainee . . . shall be discriminated against because of sex, race, or color, and, where separate

schools are required by law for separate population groups, to the extent needed for trainees of each such group, equitable provisions shall be made for facilities and training of like quality."

Section 601 of the Regulations provides that "all departments and agencies of the Government of the United States concerned with vocational and training programs for defense production shall take measures to assure that such programs are administered without discrimination because of race, creed, color, or national origin."

An institution will not, however, be required to admit to an E. S. M. D. T. course any person excluded from its student body by existing laws, rules, or regulations.

22. *What number of trainees may be admitted to a course?*

Institutions will be expected to restrict the enrollments in courses to the numbers they can effectively handle with available facilities in staff and equipment. Within this limitation, the number of persons to be admitted to each course is to be determined on the basis of estimated existing and anticipated needs for trainees in defense activities. A direct relationship must be maintained between the numbers trained and estimated needs. (See question 33.)

23. *What personal expenses do E. S. M. D. T. trainees incur?*

E. S. M. D. T. funds are intended to meet all expenses of the institution ordinarily covered by tuition fees, student health fees, and laboratory charges. Hence no such fees or charges are to be required of E. S. M. D. T. trainees. These funds may also be used to provide trainees with miscellaneous supplies, materials, and reference books such as are usually furnished by the institution to its regular students in similar courses, and drawing instruments on a loan basis. Trainees are expected to provide their own subsistence, textbooks, transportation (except on required inspection trips), and such incidental materials and supplies as notebooks, paper, pencils, and erasers.

Trainees may also be required to make such deposits as the institution normally requires of its regular students to assure proper use and return of institutional property. These deposits are to be refunded on return of this property in good condition.

24. *Will trainees be deferred from Selective Service?*

Deferment under the Selective Service is a matter for decision by the local boards, and E. S. M. D. T. trainees will not necessarily be deferred. Encouragement has been given to these boards, however, by the Selective Service headquarters to defer persons in training in the fields covered by the E. S. M. D. T. program. E. S. M. D. T. trainees who are subject to call for service should request the college authorities to give their local boards full information concerning their training status.

25. *What aid will be given in placement?*

Participating institutions should actively assist trainees in finding employment through their own employment services and by keeping the Civil Service Commission and public employment offices advised as to courses being conducted and persons available for placement.

D. Educational Administration

26. *What institutions are expected to offer courses?*

Only such institutions as are eligible under the Act (see question 6), and already have available suitable facilities in staff and equipment to assure sound instruction at reasonable cost are expected to offer E. S. M. D. T. courses. An institution will not be approved to give courses for the training of engineers, chemists, physicists, or production supervisors under the program unless in 1940–41 it granted degrees with majors or fields of specialization, containing not fewer than 18 semester hours (or equivalent) of junior- and senior-year credit in the corresponding field. "Production supervision," as used herein, includes accounting, industrial management, personnel management, employment management, statistics, and transportation. Calculus shall have been required as a prerequisite for a substantial part of the major work in physics.

Participation in the program is voluntary, and institutions should not feel obliged to propose courses that cannot be given without serious disturbance to regular institutional programs.

27. *How is the program administered within the institution?*

Each institution assumes full responsibility for administering its E. S. M. D. T. program in accordance with the provisions of its approved plan. (See question 5.) This responsibility includes the proposal of suitable courses designed to meet the needs for training as determined, the selection of qualified

teaching and supervisory personnel, recruiting and selection of trainees, expenditure of funds, keeping of records and accounts, and all other matters pertaining to the conduct of E. S. M. D. T. courses in the institution.

The chief administrative officer of each participating institution has primary responsibility for the administration of the E. S. M. D. T. program of his institution. He appoints an "institutional representative" who is responsible for coördinating E. S. M. D. T. activities within the institution, who serves as liaison officer between the institution and the E. S. M. D. T. Director and between the institution and other participating institutions, and who is a member of the regional committee under the chairmanship of the regional adviser. (See question 3.) The institutional representative shall see that all proposals, budgets, and reports are executed properly and are sent promptly to the Director, and that all information sent to him by the Commissioner or the Director relating to the E. S. M. D. T. program at the institution is conveyed promptly to the persons who may be concerned therewith.

For each course proposed by an institution a "person in educational charge" is designated who is responsible for the content and educational supervision of the course. This person is to be a regular staff member of the department under which the course is to be given.

28. *What standards apply in the selection of personnel?*

The same standards that the institution applies in the selection of its regular personnel. E. S. M. D. T. courses should not be offered if persons with suitable training, experience, and temperament can not be found to conduct them. (See also Sec. 704 of the Act quoted in the appendix.)

29. *How is compensation of employees to be determined?*

Compensation of teaching, supervisory, clerical, and other E. S. M. D. T. personnel shall conform with regular institutional salaries and established rates in the community. Heavy loads to provide substantial increases in income are not to be permitted. (See question 31.)

30. *May Federal employees receive compensation from E. S. M. D. T. funds?*

Federal employees, including members of the armed forces, may be employed to teach E. S. M. D. T. courses and their compensation may be paid from E. S. M. D. T. funds, provided their employment under the E. S. M. D. T. program

meets with the approval of the Federal agency by which they are employed, and their total loads are not excessive. (See question 31.) Dual compensation from Federal funds is not involved, since E. S. M. D. T. funds held by the institutions are considered to be institutional rather than Federal funds.

31. *What limitations are placed on the total load of employees?*

Total teaching, supervisory, and other duties of persons conducting E. S. M. D. T. courses shall be consistent with good academic standards. Regular staff members should not ordinarily be permitted to carry E. S. M. D. T. courses as a substantial addition to their regular full-time duties. Wherever practicable, the person's regular load should be reduced, a portion of his salary paid from E. S. M. D. T. funds, and the saving in regular salary funds utilized to employ additional part-time or full-time teaching personnel. (See question 29.)

32. *What benefits are employees entitled to receive?*

E. S. M. D. T. employees are entitled to receive the same benefits in vacation, sick leave, insurance, hospitalization, etc. as are regularly accorded other persons employed by the institution on a similar basis. Any costs necessary to provide such benefits are properly chargeable to E. S. M. D. T. funds.

E. Proposals

33. *How may an institution propose courses and receive a grant of funds?*

(*a*) The institution first executes and submits to the Director, in duplicate, a "Plan for Short Engineering, Science, and Management Courses of College Grade," E. S. M. D. T.—Form 3. This plan includes general provisions for the conduct of E. S. M. D. T. courses by the institution, and is to be supplemented from time to time by preliminary proposals and final proposals for specific courses. (See *b* and *c*.) No E. S. M. D. T. funds can be certified for payment to the institution until this plan has been approved. (See question 5.)

(*b*) For each course the institution wishes to offer under its plan, it prepares and submits to the Director, in duplicate, a "Preliminary Proposal," E. S. M. D. T.—Form 1. Preliminary proposals for repetition of courses already given should be executed in full. Reference to former preliminary proposals is not satisfactory. However, one preliminary proposal may cover several sections of a course, if all

have the same course content, whether in one or several localities, provided the starting dates of instruction will fall within a period of four weeks.

One copy of the preliminary proposal, when approved, is returned to the institution, with an authorization for it to organize the course and begin instruction in accordance with the provisions of the preliminary proposal, except as these may be modified by the conditions of approval stated in the authorization.

The number enrolled in each course when instruction begins must be within the limits set in the approval of the preliminary proposal. Should the institution desire to conduct the course for fewer than the minimum or more than the maximum number of trainees specified in this approval, the Director should be requested to issue a revised authorization. If the number of trainees in any course should, before the course is completed, drop below the minimum number approved, the Director should promptly be so advised with a recommendation that the course be continued or discontinued as desired by the institution.

(*c*) One week after instruction in any course has begun, the institution prepares and submits to the Director, in duplicate, a "Final Proposal," E. S. M. D. T.—Form 5, based on the actual enrollment at that time. A final proposal covering more than one section should be submitted one week after instruction in the last section is started. It should cover all sections of the course in which the starting dates of instruction fall within a period of four weeks. (See questions 34 and 35.)

If instruction in any course for which a preliminary proposal has been approved should not be started, or should be discontinued before the end of the first week of instruction, the final proposal should be submitted immediately, giving the costs incurred and the reason for discontinuance. If actual instruction in the course was not begun, the costs reported should not exceed the limit of the organization expenses authorized in the approval of the preliminary proposal. If no costs have been incurred, cancellation of the approval of the preliminary proposal should be requested immediately by letter.

If the final proposal submitted by the institution involves costs substantially out of line with the preliminary proposal, the Director will appraise the situation in consultation with the institution.

(*d*) The final proposal, when approved by the Director, serves as a basis for certification to the Secretary of the Treasury of the United States for immediate payment to the institution of the entire amount of the approved budget for the cost of the course.

34. *Is a separate final proposal required for each approved preliminary proposal?*

A separate final proposal is to be submitted for each approved preliminary proposal for which approval has not been cancelled. (See question 33.)

35. *How may changes in a final proposal be requested?*

Prior to approval of a final proposal requests for revisions may be made by letter or by telegram. Requests for changes after the proposal has been approved should be submitted in duplicate on the appropriate pages of E. S. M. D. T.—Form 5 and marked "Supplement to Final Proposal" with the name and code symbol of the course. The supplementary proposal should include only the changes desired in the approved final proposal. Thus the supplementary budget sheet should show only the additions and reductions desired in the budget items of the approved budget sheet. Supplementary proposals should be signed in the same manner as original final proposals. (See question 33.)

36. *What is meant by "cost of courses"?*

"Cost of courses" means all expenditures necessary for organization, administration, supervision, instruction, and maintenance and operation of plant in conducting E. S. M. D. T. courses pursuant to an approved plan. It may include expenses for such items as personal services; supplies and material; heat, light, and power; travel of instructors and supervisors, but not trainees; transportation of trainees on required inspection trips; physical examination of instructors and trainees; insurance, including workmen's compensation; contributions to teachers' retirement plans; communications, including postage; maintenance and repair of equipment; replacement of parts; necessary printing and duplicating; reference books and other instructional material, except textbooks, necessary as part of the instruction; necessary additional space and equipment; and national and regional coördination; provided in respect to each item, except as specifically authorized by the Director, that the institution regularly furnishes such item for its regular students or employees at its own expense or from tuition, lab-

oratory, or other fees regularly charged to the students. In addition, the institution may include in the cost of courses the cost of drawing instruments furnished to trainees on a loan basis. To provide reimbursement for costs that cannot reasonably be accounted for separately, the institution may, subject to prior approval of the Director, charge to the cost of courses a percentage of definitely ascertainable costs. Any such percentage and its basis for application must be justified in the request for approval.

Institutions will not be reimbursed for such costs as would have been incurred in their normal operations regardless of whether they had conducted courses under the E. S. M. D. T. program.

Textbooks, paper, pencils, and supplies, such as are ordinarily furnished by regular students of the institution, are to be provided by the trainees and are not to be charged to the cost of courses. (See question 23.) No space leased may be on the property of the institution, and no buildings may be purchased or erected from E. S. M. D. T. funds.

37. *Will an institution be reimbursed for the cost of courses discontinued or modified at the request of the Director?*

The institution will be reimbursed for the cost of organizing the course (see question 39) and conducting such part of it as may have been given with the approval of the Director.

38. *How are costs of courses to be classified?*

All proposals, accounts, and reports of the institution should have the items of expense entering into costs of courses classified as shown below. This applies particularly to E. S. M. D. T.—Forms 1, 2, 5, 6, and 10, and to the accounts kept by the financial officer of the institution. Organization expenses and costs of regional coördination should be classified in the appropriate items under "Administration and Supervision." Costs that cannot reasonably be accounted for separately and are to be charged as a percentage of definitely ascertainable costs (see question 36) should be classified as "Other expenses" under the appropriate general classifications if they cannot properly be assigned to the other separate sub-classifications. (See questions 36, 37, 39, 40, 42, and 44.)

A. Administration and Supervision

(1) *Personal services.* Compensation paid to administrative and supervisory officers and their clerical staffs, including auditors, secretaries, bookkeepers, etc.

(2) *Equipment.* Purchase and rental of additional equipment for administrative and supervisory use, including freight and drayage; *e.g.,* typewriters, filing cases. (Do not include consumable supplies.)

(3) *Travel.* Actual and necessary travel expenses (including subsistence) involved in organizing, administering, and supervising the approved program.

(4) *Supplies and materials.* Consumable supplies used in administration and supervision; *e.g.,* stationery, paper, pencils.

(5) *Other expenses.* Items chargeable to administration and supervision but not belonging in (1), (2), (3), or (4), above, including telephone, telegraph, postage, printing, duplicating, maintenance and repair of office equipment, etc.

B. Instruction

(1) *Personal services.* Compensation paid to teachers and their assistants.

(2) *Equipment.* Purchase and rental of additional equipment for instructional purposes, including freight and drayage; *e.g.,* drawing instruments, microscopes, drafting tables, ovens, reference books. (Do not include consumable supplies or textbooks.)

(3) *Travel.* Actual and necessary travel expenses (including subsistence) of teachers and assistants on trips directly chargeable to instruction and transportation (but not subsistence) of trainees on required inspection trips.

(4) *Supplies and materials.* Consumable supplies and materials used in connection with instruction and not customarily furnished by students, *e.g.,* chemicals, testing specimens, drawing supplies, examination paper.

(5) *Other expenses.* Items chargeable to instruction but not belonging in (1), (2), (3), or (4), above, including maintenance and repair of instructional equipment, printing and duplicating of instructional material, etc.

C. Maintenance and Operation of Plant

(1) *Personal services.* Compensation paid to janitors and others engaged in maintenance and operation of plant.

(2) *Space.* All expenditures for leasing of space and minor building alterations.

(3) *Travel.* Actual and necessary travel expense (including subsistence) in connection with the maintenance

and operation of the plant for E. S. M. D. T. courses. Ordinarily there should be no expense chargeable to this classification.

(4) *Supplies and materials.* Consumable supplies and materials used in maintenance and operation of plant; *e.g.*, janitorial supplies.

(5) *Other expenses.* Items chargeable to maintenance and operation of plant not belonging in (1), (2), (3), or (4), above, including heat, light, power, water, etc., used in excess of amounts required for the institution's normal operations.

39. *What is meant by "organization expenses"?*

All expenses incurred by the institution incident to organizing a course up to the time instruction begins are termed "organization expenses." They may include the cost of such items as surveys of needs made with the approval and under the direction of the regional adviser; publicity (see question 16): preparing course outlines, proposals, records, and reports; tentatively securing staff members; and recruiting, interviewing, and registration of prospective trainees. They do not include any costs of actual instruction. Reimbursable organization expenses may not exceed the amount authorized in the approved preliminary proposal without specific approval by the Director.

If instruction in the course is not begun for any reason, organization expenses should be reported, properly classified (see question 38), on a final proposal form with the reason for not proceeding with instruction.

Organization expenses for a course in which instruction is actually begun are integrated in the final proposal with other costs of the course.

F. Fiscal Administration

40. *What limitations are placed on expenditures for equipment and space?*

The Act provides "that not to exceed 20 per centum of the amount allotted to any school shall be allotted to it for expenditure for purchase and rental of additional equipment and leasing of additional space found by the Commissioner necessary to carry out its approved plan."

The 20 per cent limitation does not necessarily apply to a single proposal, but no final proposal can be approved if the total

amount budgeted for equipment and space in that proposal and all final proposals already approved exceeds 20 per cent of the total budgeted cost. Further, the total *expenditures* by the institution under its approved plan for these items shall not exceed 20 per cent of the total of all *expenditures* of the institution under its plan. The necessity for all equipment and space items must be justified by adequate information in the proposals. Only such equipment and space items as are listed in approved final proposals and approved supplements thereto can be charged to E. S. M. D. T. courses.

41. *Who holds title to equipment purchased?*

Any equipment purchased by the institution under its approved plan shall at all times be held available for use in E. S. M. D. T. courses, and, to the extent not needed for the E. S. M. D. T. program in the institution, shall be subject to disposition by the Director for use elsewhere in the program. For these purposes title to equipment shall be held by the institution.

42. *How are funds to be expended?*

All funds paid to an institution under its plan are to be held by the financial officer authorized to receive and receipt for Federal funds and expended in accordance with the regulations applicable to other funds of the institution. For example, reimbursement for travel expense is to be made in accordance with the institution's regulations governing such reimbursement, not with those of the Federal Government.

Expenditure of funds must be solely for such purposes as are authorized by the Act and the Regulations and in accordance with the provisions of the approved plan of the institution.

At the termination of the E. S. M. D. T. program, the institution is to return with its final report (see question 45) any unexpended and unencumbered balance, including interest earned, if any, by drawing its check to the order of the Treasurer of the United States for the amount of such balance and sending said check to the Director for transmittal to the United States Treasury.

43. *Who is responsible for loss or misappropriation of funds?*

The institution must make good any loss or misappropriation of E. S. M. D. T. funds.

44. *What are the requirements for keeping and auditing accounts?*

The institution is to maintain such separate accounts of E. S. M. D. T. funds received and expended under its approved plan

as will serve to permit an accurate and expeditious determination to be made at any time of their status, including the disposition of all moneys received and the nature and amount of all charges claimed to lie against them. (See question 38.) The accounts will be supported by separate requisitions and vouchers properly approved for all charges. A separate bank account is not required. The institution may, at its option, keep separate income or separate expenditure accounts for each course.

At the conclusion of the E. S. M. D. T. program, a complete audit of the accounts is to be made for the institution by the certified public accountant or state auditor who regularly audits the accounts of the institution. Immediately after this audit has been made, a certificate of the auditor, certifying to the accuracy of the final report (see question 45) and compliance by the institution with the provisions of its approved plan in respect to its expenditures, is to be submitted to the Director.

Auditors of the Federal Government may inspect these accounts at any time.

G. Records and Reports

45. *What reports are required of institutions participating in the program?*

(*a*) A letter on the day instruction begins in each course or section, giving the name and code symbol of the course, the location, and the beginning enrollment.

(*b*) A registration card (proper half of E. S. M. D. T.—Form 8) for each trainee for the first E. S. M. D. T. course in which he enrolls. (Such a card is not required for subsequent enrollments of the same trainee in E. S. M. D. T. courses. It is required, however, for each E. S. M. D. T. trainee regardless of whether he enrolled in any course in the earlier E. D. T. program.)

(*c*) A monthly enrollment report for each course on E. S. M. D. T.—Form 9, as of the last day of each calendar month, to be received in Washington not later than the 10th of the succeeding month.

(*d*) A monthly financial report on E. S. M. D. T.—Form 6 covering all receipts and expenditures of the institution under its approved plan as of the close of each calendar month, to be received in Washington not later than the 20th of the succeeding month. (See question 38.)

(*e*) A final report on E. S. M. D. T.—Form 10, made within four weeks after June 30, 1942, or within four weeks after termination of the last course conducted by the institution under its approved plan should any course continue after June 30, 1942. (See questions 42 and 44.)

(*f*) Such other reports in such form and containing such information as the Commissioner or the Director may from time to time require.

46. *What records of trainees should be kept by the institution?*

It is recommended that complete attendance and scholastic records be kept by the institution for each E. S. M. D. T. trainee in the same manner that such records are kept for regular students of the institution. Such records may have considerable future value.

47. *Should certificates be given to trainees?*

Each trainee who satisfactorily completes an E. S. M. D. T. course is to be given some evidence of such completion. A certificate is recommended but not required. A suggested form of certificate will be furnished to any participating institution upon request.

III. Appendix

Excerpts from the Labor-Federal Security Appropriation Act, 1942.

Title II. Federal Security Agency

Education and Training, Defense Workers (National Defense)

Payments to States, and so forth (national defense): For payment to States, subdivisions thereof, or other public agencies operating public educational facilities, and, where hereinafter authorized, to vocational schools exempt from taxation under section 101 (6) of the Internal Revenue Code, colleges and universities, for the furtherance of the education and training of defense workers, through certification from time to time, in accordance with regulations promulgated by the United States Commissioner of Education (hereinafter referred to as the "Commissioner") under the supervision and direction of the Federal Security Administrator and approved by the President, by the Commissioner to the Secretary of the Treasury of the name of such agency or the name of such school, college, or university to whom payment is to be made, and the amount to be paid, such payment to be made prior to audit and settlement by the General Accounting Office as follows: . . .

(3) For the cost of short courses of college grade provided by degree-granting colleges and universities pursuant to plans submitted by them

and approved by the Commissioner, which plans shall be for courses designed to meet the shortage of engineers, chemists, physicists, and production supervisors in fields essential to the national defense, and such plans may provide for regional coördination of the defense training program of the participating colleges and universities, $17,500,000: Provided, That only colleges and universities which operate under charters which exempt their educational property from taxation and public degree-granting educational institutions shall be eligible to receive funds herefrom: Provided further, That not to exceed 20 per centum of the amount allotted to any school shall be allotted to it for expenditure for purchase and rental of additional equipment and leasing of additional space found by the Commissioner necessary to carry out its approved plan. . . .

. . . The Commissioner shall transmit to Congress quarterly during the fiscal year ending June 30, 1942, a report of the defense training programs and training programs for youth employed by the National Youth Administration on work projects covering such educational programs which operate under his administration, as provided for in this Act, such reports to show the distribution of Federal funds and activities by States, types of programs and numbers of persons trained. . . .

No trainee under the appropriations provided for in the foregoing paragraphs 1, 3, and 4 shall be discriminated against because of sex, race, or color, and, where separate schools are required by law for separate population groups, to the extent needed for trainees of each such group, equitable provisions shall be made for facilities and training of like quality.

Selection of trainees under the foregoing programs of training shall be based upon the existing and anticipated need for defense workers in occupations essential to the national defense. . . .

The Commissioner may delegate to any officer in the Office of Education any of his powers or duties hereunder.

Title VII. General Provisions

Sec. 704. No part of any appropriation contained in this Act shall be used to pay the salary or wages of any person who advocates, or who is a member of an organization that advocates, the overthrow of the Government of the United States by force or violence: Provided, That for the purposes hereof an affidavit shall be considered prima facie evidence that the person making the affidavit does not advocate, and is not a member of an organization that advocates, the overthrow of the Government of the United States by force or violence: Provided further, That any person who advocates, or who is a member of an organization that advocates, the overthrow of the Government of the United States by force or violence and accepts employment the salary or wages for which are paid from any appropriation contained in this Act shall be guilty of a felony and, upon conviction, shall be fined not more than $1,000 or imprisoned for not more than one year, or both: Provided further, That the above penalty clause shall be in addition to, and not in substitution for, any other provisions of existing law.

MINUTES OF COUNCIL MEETINGS *

Present: D. B. Prentice, L. E. Conrad, F. L. Bishop, H. H. Armsby, H. T. Heald, Jas. S. Thompson, R. B. Wiley, R. C. Ernst, V. M. Faires, H. A. Fisher, L. G. Straub, B. M. Woods, W. Otto Birk, H. A. Curtis, C. S. Ell, D. P. Savant, G. T. Seabury, D. C. Jackson, A. N. Talbot, Anson Marston, A. M. Greene, C. F. Scott, A. A. Potter, R. L. Sackett, R. A. Seaton, W. E. Wickenden, C. C. Williams, H. P. Hammond, S. B. Earle, O. J. Ferguson. (30)

President Prentice gave a brief summary of his work during the year. In addition to numerous meetings in Washington and Pittsburgh in connection with defense, he attended four meetings of sections of the Society—Allegheny, Illinois-Indiana, Ohio and Texas. He also reported on his work as Chairman of the Membership Committee. (See report of secretary for details.)

The report of the *secretary,* F. L. Bishop, was read and approved.

The report of the *auditor* constitutes the report of the *treasurer.* In the absence of Mr. Wiley, the secretary presented the report which was accepted.

Fifty-four members were dropped for non-payment of dues—$15 each.

Special funds appropriated:

$500 to the Engineers' Council for Professional Development for the work of the Committee on Engineering Schools.

$250 to the Division on Engineering Drawing to defray in part expenses of the survey of engineering drawing.

$200 to the Division on Mechanics to defray in part expenses of the investigation of objective achievement tests.

1943 meeting.—The invitation of the Illinois Institute of Technology and Northwestern University to hold our 50th anniversary meeting in Chicago in 1943 was accepted. A Working Committee to arrange for the celebration of our 50th anniversary was authorized—H. P. Hammond, Chairman, S. B. Earle, K. T. Compton, O. J. Ferguson, D. B. Prentice, A. H. White. The Honorary Committee will consist of all charter members.

Conference on Aircraft Structures, at New York University, September 5–6, 1941, was approved.

* 49th Annual Meeting, University of Michigan, June 23–27, 1941.

The secretary was authorized to issue a *Special Bulletin* * in July.

Representatives elected:

American Council on Education—D. B. Prentice.

Engineers' Council for Professional Development—C. C. Williams.

Year Book.—It is the opinion of Council that the year book is published for the benefit of the members of the Society and copies should be sent only to members, educational institutions, and other educational organizations.

Committee on Relations of Engineering Schools to Secondary Schools.—The appointment of a committee of five was authorized.

Dues.—A request that dues for 1941–42 be $4.50 instead of $5.00 was tabled. A request that 50c be given to sections for each member who paid his dues before a given time was also tabled.

Life Membership.—Three requests for exemption from the payment of dues were received. Two were rejected. The application of E. F. Chandler, a member since 1907, 66 years of age, and retired from active professional life, was accepted.

Comprehensive Examinations.—At the request of this Committee, the present personnel is to continue for 1941–42, and plans for a Division on Comprehensive Examinations was referred to the Committee on Relations of Divisions to the Society.

Mathematics.—This Division is compiling a list of problems covering various engineering fields. When properly edited by a committee appointed by the Division, the request for approval of the publication of these problems will be referred to the Publication Committee of the Society which will report back to the Council.

English.—The Chairman of this Committee, O. J. Ferguson, reported on the work and discussed the conference of teachers of English to be held at the University of Michigan immediately following our meeting.

Acceleration of Regular Engineering Programs.—The Chairman, D. B. Prentice, presented a report which covered the work of this Committee. The report had been published in the March 1941 issue of THE JOURNAL OF ENGINEERING EDUCATION. (Council took no action in regard to the Committee. At a meeting of the Executive Committee, after the adjournment of the meeting, information was presented which made it seem desirable to continue the committe.)

* This was mailed to all members. The Bulletin contained the latest information available at that time on the defense program and was prepared by R. A. Seaton, Director of E. D. T.

Nominating Committee.—Members, who were serving the first year of their terms as members of the Council, were invited to attend the meeting of this Committee this year and also in the future.

Sections and Branches.—The report of the Chairman, L. E. Conrad, was received with appreciation of the work done. Approval was given to the dissolution of the Arkansas-Oklahoma Section; to the formation of the Southwest Section; and to the formation of the Worcester Polytechnic Institute Branch.

Resignation of Treasurer in 1942.—Mr. W. O. Wiley, Treasurer of the Society since 1907, presented his resignation effective June 30, 1942. Council, with much regret and appreciation of his faithful services, accepted this resignation and appointed two committees, one to select his successor—A. R. Cullimore, Chairman, O. J. Ferguson and B. M. Woods; and one on the recognition of Mr. Wiley's services to the Society—A. M. Greene, Chairman, F. E. Turneaure, and Jas. S. Thompson.

Amendments to the Constitution.—The report * of the Committee on Election Procedure, recommending the enlargement of the Nominating Committee, was presented by the Chairman, A. H. White. Suggested amendments to the Constitution were received from Past President C. Frank Allen. The recommendations suggested in the above were accepted in principle and referred to a committee for phrasing—L. G. Straub, Chairman, W. Otto Birk and H. H. Armsby. When the changes in the Constitution are received from this Committee they will be sent to each member and will be acted upon at our 50th annual meeting in New York City, June 29–July 2, 1942.

Reports

S. P. E. E. Representatives on E. C. P. D.

The report presented by the Chairman, R. A. Seaton, appears on page 132.

Supplementing the report presented by Dean Seaton, particular phases of the work of E. C. P. D. were presented briefly by several chairmen of its committees who were present—A. A. Potter, Committee on Engineering Schools which conducts accrediting; D. C. Jackson, a new Committee on Principles of Engineering Ethics; R. L. Sackett on Selection and Guidance; and C. F. Scott on Professional Recognition. A summary of the presentation by the last two follows:

* This report had been presented to the Council for letter ballot earlier in the year. The consensus of Council was that the report should be submitted for discussion to the Council at its meeting, June 23–27, 1941.

Selection and Guidance—E. C. P. D.—The members of the committee request that the Council of S. P. E. E. give its approval to a continuation of the study of admission practices and guidance including the use of tests for various purposes. This will continue to be a joint project of E. C. P. D. and S. P. E. E.

This will be made possible through financial support of A. R. Cullimore, President of Newark College of Engineering.

Following this report Council expressed its appreciation of President Cullimore's generous support of the foregoing project.

Professional Recognition—E. C. P. D.—This Society urges upon engineering teachers that they interest their students in the engineering profession, its history and present status, its opportunities and obligations. Pertinent articles are planned for THE JOURNAL OF ENGINEERING EDUCATION.

RELATIONS OF DIVISION TO THE SOCIETY

This Committee recommends that

A. In general, divisions of the Society should be autonomous and self-sustaining except that

1. If new undertakings or procedures are to be started, proposals embodying their essential features should be submitted to the Executive Committee for review as to conformity with general policies of the Society, and

2. Limited grants of funds may be made by the Executive Committee of the Society for activities of the divisions effecting the general welfare of the Society, or the annual programs of the divisions, upon request by the officers of the divisions, but the total amount so granted to all divisions in any one year shall not exceed $500 without special action of the Council.

B. That a special committee of the Society be appointed for one more year to explore with the divisions any special problems concerning relations of divisions to the Society that should receive further consideration.

R. A. SEATON, *Chairman*

Institutional Membership.—This Committee reported

1. Elected to active institutional membership:
   University of Connecticut
   University of Alaska
   New Mexico School of Mines
   University of Denver
2. Promoted from associate to active institutional member.
   George Washington University
   Manhattan College
   North Dakota Agricultural College

3. Eligible but not active institutional member.
   University of Nevada
4. Elected to associate institutional membership.
   Arkansas Polytechnic Institute
   Ohio Mechanics Institute
5. Application for associate inst. membership pending.
   Philadelphia Textile School of the Philadelphia Museum of Art

R. A. SEATON, *Chairman*

BRITISH CIVILIAN TECHNICAL CORPS

Resolved: That the Council of this Society endorses the work of the British Civilian Technical Corps in recruiting personnel in this country for service in England, and will coöperate in every way possible.

J. W. Burley, Pratt Institute, and O. W. Boston, University of Michigan, were appointed by the Council to coöperate with Director A. L. Cook, Pratt Institute, in any way that he may see fit.

The Council of the Society urges the coöperation of all engineering colleges in this work.

RESOLUTION ON DEFENSE TRAINING

WHEREAS, during the past academic year the engineering colleges of the nation have responded to the call to aid in the national defense by adding to their regular programs of instruction the training of large numbers of special students under the Engineering Defense Training program, be it therefore

Resolved: That the Council of the Society for the Promotion of Engineering Education reaffirms its support of similar measures which may be undertaken in addition to the normal programs of engineering education that are demonstrating their effectiveness in the present emergency, and, we believe, are preparing for the period of reconstruction when the emergency shall have passed.

Budget for 1941–42 approved.

Receipts:

Current dues, individual 2600	$13,000	
institutional 157	2,355	$15,355.00
Back dues		900.00
Advertising		2,200.00
Sale of publications and emblems		450.00
Total estimated receipts		$18,905.00

Disbursements:

Meeting	$1,000	
Journal and Proceedings	8,000	
Committees and conferences	700	
Honorarium of Secretary	2,000	
Clerical assistance	4,000	
Sundry printing	300	
Postage, telegraph, telephone	800	
Travel expenses, officers to section meetings	300	
Engineering defense emergency	700	
Travel, Secretary's office	400	
Dues: American Council on Education	100	
Contribution E. C. P. D. Com. Eng. Schools	500	
Engineering Drawing Division	250	
Mechanics Division	200	$19,250.00
Estimated deficit		$ 345.00

Members elected at annual meeting:

BARTLETT, RUSSELL S., Researcher in Engineering Education, Newark College of Engineering, Newark, N. J.

BOHL, LEIGHTON T., Professor of Civil Engineering, Brown University, Providence, R. I.

CLARK, ADRIAN N., Editorial Dept., D. Van Nostrand Co., Inc., 250 Fourth Avenue, New York City.

DOBBS, FREDERICK E., Principal, Wentworth Institute, Boston, Mass.

DOWMAN, WILLIAM S., Sales and Office Personnel, Goodyear Tire & Rubber Co., Akron, Ohio.

FIELD, WOOSTER B., Professor of Engineering Drawing, The Ohio State University, Columbus, Ohio.

FLETCHER, LEONARD J., Director, Training and Public Relations Dept., Caterpillar Tractor Co., Peoria, Ill.

GEHMAN, HARRY M., Professor of Mathematics, University of Buffalo, Buffalo, N. Y.

INGERSOLL, LEONARD B., Professor of Physics, University of Wisconsin, Madison, Wis.

JOHNSON, ALBERT P., Assistant Director of Personnel, Purdue University, Lafayette, Ind.

JOHNSON, RALPH R., Industrial Coördinator, University of Detroit, Detroit, Mich.

KENNEDY, ROBERT E., Secretary, American Foundrymen's Association, 222 W. Adams St., Chicago, Ill.

MACFADYEN, KENNETH A., Instructor in Mechanical Engineering, Newark College of Engineering, Newark, N. J.

MARIN, AXEL, Associate Professor of Mechanical Engineering, University of Michigan, Ann Arbor, Mich.

MILLER, WILLIAM B., Instructor in Science, School of Engineering Science, Sandwich, Mass.

MOGENSEN, ALLAN H., Supervisory Training in Work Simplification, 330 West 42nd St., New York City.

PHELPS, JOHN M., Admissions Counselor, Rose Polytechnic Institute, Terre Haute, Ind.

PHILLIPS, EDMUND J., Assistant Professor of Structural Engineering, Fenn College, Cleveland, Ohio.

PORTER, GEORGE M., Associate Professor of Electrical Engineering, Carnegie Institute of Technology, Pittsburgh, Pa.

POTTER, JAMES H., Instructor in Mechanical Engineering, Johns Hopkins University, Baltimore, Md.

RINEHART, H. WADE, Personnel Dept., E. I. duPont de Nemours & Co., Wilmington, Del.

SHIPLEY, EDWOOD D., Associate Professor of Electrical Engineering, University of Tennessee, Knoxville, Tenn.

TORRANCE, CHARLES C., Assistant Professor of Mathematics, Case School of Applied Science, Cleveland, Ohio.

TWENEY, GEORGE H., Instructor in Aeronautical Engineering, University of Detroit, Detroit, Mich.

WHITE, ALBERT E., Director, Engineering Research Dept., University of Michigan, Ann Arbor, Mich.

Active institutional membership: UNIVERSITY OF DENVER, Denver, Colo., Caleb E. Gates, Chancellor, C. M. Kundson, Dean.

Respectfully submitted,

F. L. BISHOP, *Secretary*

REPORT OF S. P. E. E. REPRESENTATIVES ON E. C. P. D.

The eighth annual report of E. C. P. D. has been published and widely distributed. "A Report to the Boards of Constituent Bodies" by the Chairman of the Council, R. E. Doherty, was published in the May number of THE JOURNAL OF ENGINEERING EDUCATION. These reports include carefully prepared and comprehensive statements of the present status of the E. C. P. D. program and plans for its future development. They are available to, and should be carefully studied by, every member of the S. P. E. E. and the other constituent bodies of E. C. P. D.

The work of E. C. P. D. must not be left entirely to the official representatives of the constituent bodies, if it is to develop as it should. Every member of each of these groups should be actively interested in this important work, making constructive suggestions and helping to make effective the policies and procedures adopted for "enhancing the professional status of the engineer."

E. C. P. D. portends a new era in engineering and in engineering education. Advancing science and progressive technology have been paralleled by a changing philosophy in engineering education, as was admirably traced by Dean Ferguson in the S. P. E. E. presidential address last year.

When S. P. E. E. joined in founding E. C. P. D., it formally acknowledged that the years in college include but part of the period of development of the engineer to professional status—a program in which other groups as well as teachers are concerned. These other groups, that have to do with the work of the young engineering later on, are concerned with the quality of entering freshmen, the effectiveness of training and the attitudes developed in the engineering school and in the years that follow. Engineering teachers who still consider a diploma certifying to technical

knowledge as the goal of their effort and responsibility have not caught the vision of the new E. C. P. D. era.

In E. C. P. D. a new unity is in the making—technically diverse societies, autonomous engineering schools, registration boards legalized by two score sovereign states, all join in the common purposes of developing competent engineers and of promoting the solidarity of the profession. And it is the only common agency representing us all.

S. P. E. E. is unique among E. C. P. D. groups in the matter of solidarity. The other societies are traditionally and primarily devoted to diverse technical pursuits; the registration boards are legally and geographically independent; but S. P. E. E. embraces all branches of our profession and all areas of the country. Leaders in education should be leaders in the broad scheme of comprehensive development from high school to professional status and beyond. Engineering educators and the engineering schools should be foremost in intelligent leadership in promoting the spirit of solidarity because engineering needs it and particularly because engineering students should be imbued with a just idea of engineering as a profession and as a service—an idea that will come to fruition in the future.

That the schools may accomplish this will require orientation of the teachers themselves that they may orient their students. The agency for this orientation is S. P. E. E., which should actively coöperate in promoting E. C. P. D. aims and activities. S. P. E. E. is only one of the several constituent bodies of E. C. P. D. but S. P. E. E. members constitute an important part of the leading membership of all of the other bodies. Through this membership they can and should work aggressively for general recognition of E. C. P. D. as the coördinating body for professional development and for full support by other members of the bodies in the work of E. C. P. D.

So far, E. C. P. D. has concerned itself chiefly with matters pertaining to the engineering colleges. Great areas of professional development remain almost untouched. Important matters of professional ethics, systematizing of licensing, harmonizing grades of membership, and adjusting overlapping of the work of the several societies through better definitions of the fields of engineering are as pertinent to professional development as are matters of college curricula and student selection. S. P. E. E. members should, for the common good, concern themselves with all of these problems and work for their solution.

Your representatives recommend that the usual appropriation of $500 be made by S. P. E. E. to E. C. P. D. for the fiscal year 1941–42.

(Signed) R. E. Doherty, C. C. Williams, R. A. Seaton.

MINUTES OF BUSINESS SESSIONS *

The 49th annual meeting of the Society for the Promotion of Engineering Education was held at the University of Michigan, June 23–27, 1941, with President D. B. Prentice (President, Rose Polytechnic Institute) presiding. The general meetings were held in the Rackham Building. Monday, all day, Tuesday and Wednesday afternoons were devoted to conferences. Twenty-two different groups held 69 meetings, luncheons or dinners. The members of the Council were guests of the University of Michigan at dinner on Monday evening. The first meeting of the Council was held immediately following the dinner. Council met every morning at breakfast Tuesday to Friday inclusive. There were 1,150 members and guests registered at the convention.

The first general session was held Tuesday morning with President Prentice in the chair. Ivan C. Crawford, Dean, School of Engineering, University of Michigan, and Lorin G. Miller, Chairman, Michigan Section, welcomed the Society to the University and Michigan. President Prentice responded. Alexander G. Ruthven, President, University of Michigan, addressed the Society. President Prentice delivered the presidential address: Science and Technology in the Engineering Curricula; R. A. Seaton, Director, Engineering Defense Training, U. S. Office of Education, spoke on Engineering Defense Training; A Layman's View was presented by James W. Parker, Vice President and Chief Engineer, Detroit Edison Company, also President-Elect of the American Society of Mechanical Engineers. The reports of the secretary and treasurer were read and approved. (The auditor's report comprises the report of the treasurer.)

President and Mrs. Ruthven received the members and guests at four o'clock in the Michigan Union.

The second general session was held on Wednesday June 25 with President Prentice in the chair. This session was devoted to Engineering Defense Training and was divided into two meetings. The first was a general meeting at which A. A. Potter and G. W. Case presented papers. The second was a group of conferences on this subject held by the following Divisions: Chemical Engineering; Civil Engineering; Electrical Engineering; Engineering Drawing; Industrial Engineering; Mechanical Engineering; Mineral Technology. R. A. Seaton, A. A. Potter, G. W. Case and H. H. Armsby, Engineering Defense Training, U. S. Office of Education, were available at the different conferences to answer any questions which arose.

* 49th Annual Meeting, University of Michigan, June 23–27, 1941.

The third general session was held on Thursday, June 26, with Vice President L. E. Conrad in the chair. D. C. Jackson, Massachusetts Institute of Technology, presented the following resolution which was unanimously adopted:

The Society for the Promotion of Engineering Education expresses its thanks to Dean R. A. Seaton, Dean A. A. Potter and Dean G. W. Case for their clear exposition of the need for special Engineering Defense Training and of the procedures now in effect.

The Society feels reassured that the engineering colleges will receive full support for their Engineering Defense Training work as it is expanded to meet the needs arising in the present emergency, and full support also in maintaining their regular engineering educational processes which are proving of notable service in defense measures and which will prove of equally notable service in future reconstruction processes.

The Society endorses the work of Deans Seaton, Potter and Case and their associates under the supervision of The United States Commissioner of Education.

Science in the Engineering Curricula was the topic of this session. Mathematics was presented by E. R. Hedrick, University of California at Los Angeles; Chemistry by W. N. Jones, Carnegie Institute of Technology; Physics by E. U. Condon, Westinghouse Research Laboratories; Mechanics by R. A. Dodge, University of Michigan.

The annual dinner was held at seven and President Prentice presided. L. A. Hopkins, Director of the Summer Session, University of Michigan, spoke a few words of welcome. The Nominating Committee presented the following for officers and members of the Council. They were unanimously elected:

President: A. H. White, University of Michigan.
Vice Presidents: H. T. Heald, Illinois Institute of Technology; F. L. Eidmann, Columbia University.
Secretary: F. L. Bishop, University of Pittsburgh.
Treasurer: W. O. Wiley, John Wiley & Sons, Inc.
Members of Council to serve three years:
J. H. Belknap, Westinghouse E. & M. Co.
A. C. Callen, Lehigh University.
F. M. Dawson, State University of Iowa.
N. W. Dougherty, University of Tennessee.
Seibert Fairman, Purdue University.
C. J. Freund, University of Detroit.
R. P. Hoelscher, University of Illinois.

J. H. Belknap, Chairman of the Committee on Lamme Award, presented the report of that committee recommending for the fourteenth recipient of the Lamme medal Anson Marston, Iowa

State College, "for his leadership and service in the profession of engineering, for his vision and initiative in broadening the engineering curricula, for his enterprise in guiding his students to the balance of engineering skill and artistic appreciation, for his foresight as a pioneer in the field of engineering extension, and for his untiring efforts in promoting a closer coöperation between government and engineering colleges."

Wm. M. Lewis, President, Lafayette College, Director, Selective Service System, Commonwealth of Pennsylvania, addressed the Society on National Defense and Engineering Education.

The fourth and last session was held on Friday morning, June 27, with Vice President Conrad in the chair. This was an open meeting of institutional delegates. The following papers were presented: Responsibility of the Engineering Colleges for the Present Chaos in Industrial Relations, by T. W. Prior, Goodyear Tire Company; Safety in College Shops, by C. W. Beese, Purdue University; Engineering Aptitude Tests, by C. V. Mann, Missouri School of Mines; Report of the Committee on Student Selection and Guidance, R. L. Sackett, Chairman, Pennsylvania State College; Reappraisal of Values in the Selection of Engineering Students, by R. S. Bartlett, Newark College of Engineering. The following report of the Committee on Resolutions was unanimously adopted:

The 49th annual meeting of the Society for the Promotion of Engineering Education at the University of Michigan, June 23–27, 1941, has been outstandingly successful from a professional viewpoint not only for the thoughtful presentation and intelligent consideration of questions of vital importance to engineering education and to the country at large, but also for the excellence of arrangements, facilities and courtesies that so greatly enhanced and promoted the serious business of the sessions, and no small part is due especially to the cordial reception of President and Mrs. Alexander G. Ruthven; the careful preparation and efficient functioning of the local convention committees under the leadership of Professor E. L. Eriksen; the splendid arrangements for women and children by Mrs. Alfred H. Lovell and her committee; the intelligent direction of affairs of the Society by its officers under the leadership of its president, Donald B. Prentice; the courteous and friendly welcome accorded by the staff of the College of Engineering and the members of the Michigan Section; therefore be it

RESOLVED: That the Society for the Promotion of Engineering Education extend its sincere thanks and appreciation to the University of Michigan and all individuals who so generously contributed their time and energy toward the success of the 49th annual meeting.

The meeting adjourned at noon *sine die* to meet in New York City, June 29–July 2, 1942.

NATIONAL DEFENSE AND ENGINEERING EDUCATION *

By WILLIAM MATHER LEWIS

President, Lafayette College and Director of the Selective Service System of the Commonwealth of Pennsylvania

I was very much impressed with the statement of your president-elect relative to the three members of the mathematical section of this Society who applied for a job in Hollywood. It took my mind back to that man you read about in the paper last year in Hartford, Connecticut, who, with others, drew lots for a Buick car. He drew number 42, paid forty-two cents, and then won the Buick.

A friend of his said to him, "How did you do that? Was that just chance?"

He said, "Chance nothing! One night I dreamt all night of the number seven, and the next night I dreamt of the number seven, and I multiplied them together and that is forty-two!"

His friend said, "Well, you're mistaken. Seven times seven makes forty-nine."

He said, "You have the education, but I have the Buick!"

That is my apology for standing before a group of technical men tonight. You have an engineering education, but I have had certain experiences, perhaps, that will make it worthwhile for me to speak as I can on the subject of national defense and engineering education. I approach it, of course, from two standpoints, that of a college president and of the director of selective service of one of our great states.

President Roosevelt said that America is the arsenal of democracy, and Governor James of Pennsylvania said that Pennsylvania is the arsenal of America; so that shows where we are in Pennsylvania at the present time.

Last fall the Governor asked me to act as director of the then infant movement of selective service. I told him that I was sorry that I couldn't do it because of the fact that the college was facing a difficult year and that I must give my best to it.

"Well," he said, "won't you be able to come just three days a week? We need a man who is not in politics. We need a leader of this movement who knows young people, because I am determined

* Presented at the annual dinner, 49th Annual Meeting, S. P. E. E., University of Michigan, June 23–27, 1941.

that we shall conduct selective service in the state of Pennsylvania in a human and in a humane way."

I call that to your attention because of something I am to say later and because it shows the high-minded attitude of the Governor.

I went back to my trustees, acquainted them with the governor's request, and asked them what they thought about it. They said unanimously that they thought I could do the college less harm in three days a week than I had done for all these years in seven, and they urged me to take the position. So that is why I am where I am. And perhaps I was interested in the project because it is the dream of every administrator sooner or later to have a new institution to run.

It would be a marvelous thing if some of us who are in administration could have twenty million dollars to build just the kind of an institution that we wish to have. In the first place, my institution would be under one roof. I would not have sixty or seventy buildings on the campus to heat and to maintain and all the other things that we have to do. I would have a different sort of curriculum, perhaps, and I would settle once and for all the question of a rigid four-year course in the negative. This from the standpoint of achievement rather than time serving.

We started out on the Selective Service program with a new state organization. We started out with a problem of registering 1,250,000 young men in Pennsylvania within three weeks with no local organization whatever. We started out with the problem of organizing 422 selective service boards, of organizing numerous appeal boards, of securing physicians and government appeal agents and legal advisors—an organization of about 3,700 people.

I wish to say to you men of the Society that I think the greatest evidence that we have had in many years of the solidarity of the American people and of the unity of our feelings, is that these thousands of people in the various states of the union—3,700 in Pennsylvania, more than that in New York State, thousands in the state of Michigan, and so on—stepped forward to do their part. Many of them are devoting approximately all their time to a very thankless task simply because of their love for this country of ours. I am sure that on the sixteenth of last October when the millions of boys came up for that registration, it was a disappointment to the totalitarian leaders who thought there would be something of the old draft riots of the Civil War, but nothing did occur that reflected discredit on our people.

Those who believe that America has gone soft and that beneath the surface there are elements that are weakening us, should have

a second thought as they appreciate what is being given to this nation.

I travel over the state a great deal, and I want to say to you, who may have questioned, the policy of our government in dividing and decentralizing this movement so that perhaps on one side of a line in a city a certain boy is deferred because he is going to a college and on the other side a boy in the same circumstances is not deferred; a situation where a man on one side is deferred because of dependents and on the other side a man who seems to be in practically the same position is not deferred because of dependents, that that is democracy in action. I would a whole lot rather have those variations occur than to have the whole thing handed down, cut and dried, by a bureaucracy in Washington. I feel that very strongly, and as I see this movement in action, I am sure that every week it goes on, there is more unity.

We know that today those boys who are in training schools for engineering are being deferred very generally. We know that when the first boys were called up, the average selective service board in our state knew very little about what was going on within the college walls, because of the fact that they were not college men for the most part. They didn't always have an appreciation of what the American colleges and the American technical schools are doing. So it was little wonder that they at first ruled against student deferment.

Today they are deferring engineering students and medical students. Just a little while ago a bulletin was issued from Washington stating that not only engineering students but also students majoring in biology, geology, physics, and chemistry should be considered carefully for deferment. And then there came out a supplementary bulletin stating that while they had named the engineers and the medical students and geologists and biologists, that they didn't mean that they should not defer other college students for good cause.

So I feel that more and more as this enterprise goes on, this new piece of machinery is gearing into the educational needs of the country. But I want to say to you that I still believe that not all college students should be deferred. I still think there are those in our colleges for whom a year in the Army would mean a whole lot more than a year in college. Certainly it would mean a whole lot more to the college to have them in the Army.

So we are beginning to get direction, and to tune in to American life. You realize, as I do, that we cannot have group deferment. It would not be fair to take all the engineering students and defer them as a group when you do not defer other groups.

That would be undemocratic. We have to be very careful of the direction in which we are going at any particular time in order to develop the most effective type of national defense.

That is what we are trying to get in this selective service program. We are trying to get the right direction, and we have discovered a very great many things of interest that I wish to speak to you about as briefly as I may.

In the first place, we were called upon to build up a state headquarters staff almost over night. Today we have over sixty in the organization and in that group are legal advisers, occupational deferment experts, procurement officers and other experts.

When we got down to selecting the experts for occupational deferment, we found a group of men who had at least ten years' training in that field, and we at once sent them out to make contact with the industrialists of the state of Pennsylvania in connection with the matter of necessary men in their plants.

In the plants we found great differences of policy as to those who should be deferred and those who should not be, and when our reports began coming back from our occupational deferment men, it was discovered that there are industrial plants which are doing a good job, which are telling us honestly who should be deferred and who should not. However, there have been some industrial plants that have claimed deferment for men as necessary workers where we have found out those men were shoveling slag or doing some other unskilled work. For the most part, where we have found trained personnel men in charge of the work in any given industrial institution, we have found fairness, we have found honesty, and above all, intelligent discrimination.

I want to say to this great group of engineering officials here tonight that there are not ten per cent enough trained personnel officers to go around in the industrial plants of our state today, and I suspect that is true throughout the country. I think tomorrow in our industrial training, particularly in engineering colleges, we must make more provision than we have ever made before for the development of those men who have to do with the human relations of men in industry. That is one of the greatest challenges to engineering education.

I heard not long ago of a little boy who was playing around the living room of his house. He was making a lot of noise and was making himself generally disagreeable, and his father couldn't read his magazine. So he turned to the back page where there was a map of the world, tore out the page and then tore the map into small pieces as you would a jig saw puzzle, and he said to the little boy, "Here, put it together."

He thought that would keep him quiet for at least an hour, but soon the boy said, "Daddy, I'm finished." The father looked, and the map was perfect. He said, "How in the world did you do that!" The little boy said, "I looked on the other side, and there was a picture of a man, and I put the man together, and the world was all right."

There you are. He put the man together, and the world was all right. I am suggesting to you tonight, to you who have so much to do with putting things together, that the great thing that we need to put together are the relations of human beings, particularly in industry.

Another experience that we had in the selective service program was the development of the proper morale among those who expected to go into the armed forces of the United States. As you know, those boys received their first physical examination from the local doctor, and then after a time, if they passed there, they were sent up to an induction station, and there they received their final examination. Under this system, many of them, after having given up their jobs, having sold their automobile, having had a "going away" party or banquet, have had to sneak back into town two days later having been rejected on the final examination.

So we, in Pennsylvania, made a very strong request of the authorities at Washington that, in Pennsylvania at least, those boys should have their final examination at least ten days before they were called to the colors, and that system is in operation today in Pennsylvania. You can do a great deal in the various states which you represent in asking that that sort of a square deal be given to the youth of our country.

As we go on in this critical situation, we realize on the academic side and on the official side that there are two problems of national defense today facing America. One is the problem of emergency defense, the problem which has to do with this tremendous development of industry and of selective service and the rest. But there is a far vaster problem for engineering officials, for college presidents, and others to face today, and that is that long conflict that is going to follow this war.

We still pray to God that our country will be kept out of the maelstrom of hatred and death which spreads over Europe, but there isn't a chance in a million that the boys who are now in the engineering schools of America will not be involved throughout their entire lives in a great economic and social and political struggle forced upon them by the totalitarian powers. And the one question which comes there, is a question of preparation.

The great question today is not, "Will America have guns enough and planes and man power enough in time?" The ques-

tion is, "Can we mobilize the brains, the inventive power, the ideals of the republic before it is too late?"

Up to the present time there is no question of the fact that Hitler is far ahead on the mental front as well as the battlefront. His organization, right straight through, has been like a finely trained football team that has had its scouts out to watch the opponent and know the type of play which they are using, and which are using plays that have never been used before. On the other hand, the Allies have been like a team that has not done any scouting, that does not know the Notre Dame type of play from the Stanford type of play, that just seems to meet each situation as it arises.

Gentlemen, I submit to you that the dangers of the defeat of the democracies can be traced more to this weakness than to any other thing. The democracies were beaten at Munich, because their opponents had a plan while there was only wishful thinking among those who wanted peace.

We are asking Britain today to state her war aims. America should be asked, before it is too late, to state her peace aims. The totalitarian powers have their five-year plan and their ten-year plan. America, if civilization is to persist, if our type of living is to be permanent, must have a fifty-year plan for these boys in our engineering schools today and for you and me. You cannot live successfully in this world with a hand-to-mouth policy such as there has been up to this time.

Just think of the Geo-Political Institute in Germany. This is an organization of 1,000 engineers, technical men, secret agents, and the rest under the leadership of one man. When they wanted to know if they could go into Poland at a certain time, they asked their weatherman on that board to give them the advice as to when to go in. When they wished to have a war of nerves with France, they asked their psychologists whether or not they could break France down by what is called the sitzkrieg. When they needed certain articles to replace rubber and other essentials for which they did not have substitutes, they had men upon that board to tell them how to do it, and in that group of 1,000 men under one man, they had the answer.

I believe that in this war and in the long struggle to follow we have not the slightest chance to win unless we get over our fear of one man power, as far as it has to do with heading up emergency enterprises in the proper way and not having committees and commissions fooling around with them while Rome burns. We have to realize that efficiency comes from the proper organization administering intelligent plans.

I am told that the engineers have their long-time plans, that in the vaults of the automobile factories in Detroit there are plans for ten or fifteen years, and blueprints for what will be developed in the automobile industry over those years. I am told that in the field of communications our great companies have their plans worked out for that long. Someone in government must take a page from the book of the engineers. If we are going to win, we are going to win through hard-headed efficiency and not through wishful thinking. We have to face certain facts, and we have to build up an organization that will make those facts possible.

Just two weeks ago at Haverford College, Mr. Hoover said to the graduating class that unless in a very short time America does better in research work that it has ever done before, that unless it works out new inventions and uses those inventions which it already has, more effectively than it has at the present time, that certainly the standard of living will fall, and almost certainly this civilization will go the way of other great civilizations. He said that for three reasons.

In the first place, he called attention to the fact that after this war is over we still have to go for many years with military manufacturing of different kinds. In other words, today, like it or not, we are on a war economy, and those factories which have spent most of their time making our clothes and our automobiles and our luxuries of various kinds aren't making them any more. Therefore, we shall have to pay more for all of the necessities of life in the next few years unless our research men give us new types of things.

In the second place, he called attention to the fact that this war will probably be won in the air, and unless we have constantly speeded up production of machines and ideas in airplane development, the battle may be lost for the democracies.

In the third place, he called attention to the fact that after the war is over there will be a situation in which there will be immense unemployment and suffering and killing taxation unless we have great new inventions and great new technological developments.

He went on to say that he believed there is not over three million dollars a year being spent in research laboratories to discover the things that will safeguard America and democracy and civilization.

As I read that article I thought of conversations which I used to have during the last World War with one of my old friends, the late James O. Hayworth, a great engineer of Chicago. I thought of those conversations because of the fact that we know tonight that Great Britain and the United States seemingly cannot build

ships fast enough to replace the ships that are being sunk in the Atlantic, and that if they can't, it may mean the loss of the war.

Mr. Hayworth was in Washington in the government shipping service, and his particular problem was to work out the building of concrete ships. They did build some of those ships in 1917 and '18, and one of those ships, up until very recently, was in the coastwise trade of one of the South American republics. Others were sunk to make breakwaters. The great problem, of course, was the lack of resiliency in the material. Only today we have a dispatch from Pennsylvania saying that they have made tests there of a new type of concrete, very much more resilient than it has ever been possible to make it before, and the inventor says that if it is adopted, we can turn out the hull of a 10,000 ton tanker in four weeks, whereas it takes us nine or ten months now to produce steel ships.

I know very little about this as compared to you scientific men, but that is just one idea that rises at the moment. I do know that in this matter of the use of concrete and the development of the cement industry in connection with our national problems that there are 160,000 miles of the main roadways of America today that need either entire reconstruction or new location. I do know that there are 24,000 bridges on main highways in the United States today that have been declared by the experts to be unsafe for mechanized armies to pass over. In case of trouble you couldn't move a mechanized force along many of our main roads in time to do any good.

You read the book by de Chambrun, "I saw France Fall," and you will find out that the German government had agents in Belgium who had lived there for years and who their neighbors thought were Belgians. When the right moment came, they organized the refugees and started them down the roads they wanted them to take and blocked the British advance and kept clear the roads up which the Germans came. That is what happens on narrow roads in time of warfare. That is one of the things in which the engineer today finds a challenge to go ahead if we are going to make the defense of America anything more than talk on paper. For what good does a great mechanized army do if you cannot move it from one spot to another?

There are just two other things that I want to suggest in connection with national defense and engineering. The first one I touched on in the matter of human relations. Here at a time when we need every ounce of industrial power that we can have, we have lost, from January 1 to May 1, 1,750,000 man days in strikes. That means that we wasted enough time to make 32 large

bombers, that we wasted enough time to make one cruiser or four submarines. It meant that while we were telling the boys to go into the Army in selective service, we were deliberately not making the guns and the tanks for them to use.

I know what the labor men say. They say that they go into communities where the cost of living has jumped up so that they can't live. They go into these communities where the emergency housing is so poor it is no place to ask a decent man to live. A great deal of it is true.

On the other hand, I know what the employers say relative to the New Deal, taxation and the government's paying more attention to the organizing of unions than it does to the working out of industrial problems.

I know all those things, and you know many more. But that is not the question today! We cannot stand and argue under these conditions! The question is, How are we going to set the wheels going at top speed. I do not believe it will ever be done by the employer on one hand and labor on the other unless in between you have a highly trained group of engineers, the industrial men of the plants who have been trained in college (as they are not always trained today) in human relations, in labor relations; who have received the finest kind of training in industrial economics taught them, not by theorists, but by engineers who know economics and who have been in active work in the industries of America within these last few years.

That is the challenge, gentlemen, to education, to engineering education of the very near tomorrow in America. We are at the end of one era and at the beginning of another. We are at the end of an era that has lasted 400 years and is going down in chaos. Why? Because of a lack of the understanding of human relations. We have considered the brotherhood of man as a phrase for a Fourth of July orator, because we haven't got the different groups of people to live together happily. If we can't live together happily in an industrial plant, how can you expect Germany and Russia to live happily together?

I know of no group of men who are sounder in their thought, who have a better chance of preaching this new gospel of human relations than the engineering professors of America, the leaders of our engineering councils, those with practical experience, with common horse sense, and with an accurate point of view.

In this connection, we must consider higher standards of human fitness in America, and again the engineer is very much involved. We in the selective service program are tremendously concerned with the physical health of America. Out of a million young men

who have been examined up to this time physically, nearly 400,000 of them have been turned back for physical disabilities. Some of them, I admit, are maimed and that sort of thing, but in the reports that I read in Harrisburg it stands out that much trouble can be traced to malnutrition. What does that mean? It means that there are hundreds of thousands of young men in America today who have never had the right amount or the right kind of food.

Gentlemen, democracy is not working correctly when that can be said with truth.

You read the report of the Labor Department for 1940, and you will find that there were 19,000 people killed in industrial accidents in the plants last year and 90,000 permanently disabled —so many that there were many millions of man hours of labor lost to American industry last year, because of disabilities of various kinds that came through the wrong sort of machines or the speed up process or what not.

What is the answer to that problem? The answer is the answer of the engineer: To have in an American city better sanitation, better housing, better water supply, better plans for air spaces in parks and all the rest, better examination of our industrial plants so that life and limb are protected. We have been making real progress along these lines as time has gone on, but we must make much more rapid progress in the days just ahead.

Gentlemen, democracy has not been in trouble because of the system, but because of the fact that we have not used the system correctly, because of the fact that we have been so eager to make money and rush ahead that we have not planned for the future of industry and we have not planned for the brotherhood of men in industrial life where the men work together; and not as this or that group opposed to each other. That is a great challenge to engineering education in its broader sense. If we can do these things and do them in time, there is no reason for that defeatism which is spreading over our land today.

The story is told of a traveler in Switzerland who, one afternoon, set out with a guide. They got up the mountainside and darkness overtook them, and they went into a chalet for the night and after they had been asleep for some hours, the traveler heard a great crash and a great rumbling and a tremendous noise. He was frightened, and he shook the guide and said, "What's happening! Is this the end of the world!"

The guide very calmly said, "No, this isn't the end of the world. When the sun begins coming up on the other side of the mountain, it touches the snow up there, and it warms it and loosens

it, and it goes crashing down in the valley with tremendous noise. As it gets up a little higher it strikes the face of the glacier, and the ice cracks with cannon-like reverberation. "No," he said, "this isn't the end of the world. This is the dawn of a new day."

I come to you tonight to say just that; you who have so much power and influence in this machine age of ours. This is not the end of the world. This is the dawn of a new day, a better day than we have ever seen if we can make engineering a broader thing than it has ever been before. I hate to use a term like this, but I mean human engineering, the gearing in of one group with another, the coöperation which we have never had to as great an extent as we should.

The plans which you develop in your industrial researches today are the basis of what America will be tomorrow. We still believe that this is the finest form of government devised by the mind of man, and because it is the finest, it is the most difficult to conduct successfully.

As I see it, the problem of tomorrow and of a very near tomorrow—before it is too late—is to raise up a generation which can meet these human issues, which can dramatize peace, which can go forward intelligently, scientifically, which can change the science of war into the science of peace.

A great writer recently called attention to the fact that the airplane, which was made for transportation, is dropping bombs made for industry upon caterpillars or tanks made for agriculture. That is how we have twisted things around. Tomorrow the science of destruction must be eliminated, and the science of construction for a new and better world must be under way. That, as I see it, is the challenge to engineering education today and tomorrow; that is the challenge which the great engineering interests of America with all their intelligence and loyalty are bound to meet triumphantly.

ENGINEERING MATERIALS *

By ALFRED H. WHITE

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Are Service Courses a nuisance to be eliminated whenever feasible, or are they desirable features in any engineering curriculum?

A service course may be defined as one taught to students whose major interest is not in the field of the department which is offering the course. The general undergraduate courses taken by all engineering students in English, mathematics, physics, chemistry, and drawing are all service courses according to this definition. Service courses became established as a matter of economy and convenience when engineering colleges had only small numbers of students and it was necessary to group them to obtain classes of an economical size. With large numbers of students this argument of necessity has lost some of its force. It is worth while to consider whether service courses are in themselves desirable or only necessary evils.

One advantage of service courses lies in the fitness of the teachers, who are experts in their fields. On the other hand, there is sometimes complaint that these teachers are interested only in training specialists and that they do not give enough consideration to the needs of the students who are taking the course as preparation for major work in another field.

Let us consider as a theoretical possibility a reorganization of any one of our schools, with the department of chemical engineering given authority to segregate its students, to choose the teachers, and to specify the program to be given the students in the subjects now taught by the service departments. Let us suppose further that the department of chemical engineering was able to find teachers with some knowledge of chemical engineering who were competent and willing to teach the various service courses. There would be a distinct advantage to the student in the amount of knowledge of chemical engineering acquired, for all of the prob-

* This paper introduced a symposium on Service Courses with particular emphasis on engineering materials which was presented before the Chemical Engineering Division at the 49th Annual Meeting, S. P. E. E., University of Michigan, June 23–27, 1941.

lems and exercises could be chosen with a view to their application to chemical engineering work. There would be a disadvantage due to narrowness of viewpoint. Mathematics would be taught, not from the viewpoint of a mathematician but from the viewpoint of the chemical engineer. The question of breadth versus narrowness of training is worthy of consideration because of the bearing it has on the question of whether service courses are a necessary nuisance or a desirable feature of an engineering curriculum. I think that each of us would like to see such an experiment tried, but I am not sure that the results would be entirely favorable.

Whatever the advantages and disadvantages of service courses, we must remember that they apply to all departments. If we believe that all engineers should obtain their knowledge of Engineering Materials from us, we must expect that the mechanical engineers will throw the same arguments back at us if we desire to teach our students some of the elementary subjects which they think can be better handled in their own departments.

Since we are all chemical engineers here, we will probably agree that Engineering Materials should be taught by a chemical engineer. Would a group of mechanical engineers or civil engineers be in agreement with us? Probably not. Some of them would object saying that the chemical engineer would load the course with too much theory and would not make it practical. The civil engineer might say that the physical testing of materials has always been taught by his department and that any amplification of the field should be made on the foundation of his existing course. The mechanical engineer might hold that since his profession had to use these materials in the design of machines to operate under the strenuous conditions of modern industrial life, he should impart the groundwork of the properties of materials as well as their behavior in actual structures.

A glance backwards at the development of our knowledge of materials used by engineers may be helpful. Fifty years ago heat treatment was an art and not a science. Roozeboom had not yet drawn up his equilibrium diagram of the iron-carbon system. The first metallographers were cautiously announcing their early work. A young Frenchman, Henri le Chatelier, had obtained his doctorate on a dissertation which showed that Portland cement contained several definite crystalline compounds. Fifty years ago science had scarcely made a dent in the traditional methods of manufacturing materials. At that time physical tests were the only ones which were widely applied, and the civil engineer could give better instructions in the properties of materials than any of his colleagues. Today the properties of materials are known to be con-

trolled by the arrangement of atoms in the unit groups and the combinations of the unit groups into other minute but more complex groups. Our knowledge is far from complete, but each year sees more theoretical background and a more systematic presentation. No one who does not have an adequate knowledge of chemistry and physics should attempt to teach a course in Engineering Materials.

The question may be raised as to whether a chemical engineer or a metallurgical engineer is better qualified to teach this course. To me any engineer who has a strong background of mathematics, physics, and chemistry, and uses these three sciences in his professional work, is a chemical engineer. His specialization may be in a field important enough to warrant a separate group name, such as metallurgical or petroleum engineering, but all of these specialized groups are functionally subdivisions of chemical engineering.

There are some schools which do not yet recognize the importance of a course in Engineering Materials as a background for all future engineers. If we eliminate from engineering all elements of economics and human relationship we find that the purely technical aspects which remain are almost all concerned with materials and forces, and their interreactions. Physics deals almost wholly with forces. Chemistry is devoting more and more attention to forces and less to a descriptive knowledge of materials. The courses in the professional departments concern themselves with the interaction of forces and materials. The professional work of the engineer deals mainly, in its technical aspects, with materials and forces. The factor which hinders more rapid progress in almost all branches of engineering is inadequacy of materials. The airplane of today has been made possible by lighter and stronger alloys, better motor fuel, superior lubricating oil, more resistant protective coatings. When these materials are improved better aircraft and better engineering structures of all kinds will result. And yet in spite of the importance of materials in the engineering world, some schools do not make even one short course in the subject a requirement for graduation.

The Course in Engineering Materials at the University of Michigan

At the University of Michigan the course was formerly taught to sophomores and juniors, and the regular freshman chemistry course was held rigidly as a prerequisite. Not many years ago a general revision of the curriculum placed this course in the freshman year and coupled it with the freshman course in Metal Processing which, in its older and rudimentary form, was known as Forge Shop.

Twenty years ago the freshman course in the forge shop was in charge of a foreman instructor who gave the students a good course in blacksmithing. About that time the faculty of the college decided that such a course was obsolete and decreed that it should be modernized. The process of modernization required time but the laboratory (no longer called a shop) now contains modern heat treating furnaces, hardness testers and a small machine for tensile tests, equipment for arc, gas, and other common welding processes, a few machine tools and about one-third as many anvils as were in the old shop. The course is in charge of a trained metallurgical engineer but there is still a foreman instructor who teaches the principles of forging. The main emphasis of the course is on the properties of the metals rather than on the operations. When a student, toward the end of the course, forges a cutting tool, he heat treats it in a scientific manner, grinds it, and then puts it to work in a machine to see if it will really operate satisfactorily as a metal-cutting tool. This course in Metal Processing is taken by the student simultaneously with the course in Engineering Materials. The two courses should, and do, supplement each other in an effective way.

In Metal Processing the student must start at once to work with metals. Therefore, in Engineering Materials the first topic is the structure of metals and the nature of alloys. Iron and steel and the non-ferrous metals follow with emphasis on the properties of the materials as affected by the processes of manufacture, fabrication and heat treatment. A little over half of the time is devoted to metals and alloys. The balance of the course is devoted to non-metallic materials. Mortars and cement are considered, with Portland cement and concrete receiving the most attention. Bricks, refractory materials, and glass receive somewhat shorter treatment. Fuels, water, corrosion, protective coatings and finally a glance at plastics fill the balance of the periods. This course is rated as a three-hour course and the accompanying course in Metal Processing gives two hours of credit. The graduation requirement is 140 hours and so these courses together comprise 3.5 per cent of the total.

The methods of teaching will depend somewhat on the size of the class. The technique at the University of Michigan has been developed to take care of a class which may number 350. The whole group meets for two lectures a week and is divided into sections for two recitations each week during the semester of approximately fifteen weeks. These recitation sections are divided among as many as six members of the staff and in order to secure a reasonable degree of coördination the lecturer makes out a list

of suggested questions on each lesson. These are duplicated and supplied to each instructor on 3 x 5 cards. It is customary for the instructor to distribute all but one of the cards to members of the class who write the answers on the blackboard. The students who remain in their seats take about ten minutes to write out their answer to the remaining question selected by the instructor for that purpose. The papers are collected, graded, and returned at the next class period. The answers on the board serve as framework for the discussion for the balance of the hour. Each student knows he will be called upon at every class period. Two or three lecture periods are used for written reviews, and there is a final examination for which a period of four hours is allowed. The final grade in the course is based on the averaged results of the daily recitations, the three review quizzes and the final examination.

The course is conducted on the open-book system and students are allowed to bring and refer to the textbook, notes, and any other reference material in the daily recitations, review quizzes, and final examinations. This procedure was introduced nearly ten years ago because of the feeling that an important purpose of the course was to teach the student how to use the literature and to understand the reasons for the various clauses governing quality in the standard specifications published by the various engineering societies. This method of teaching permits the use of a larger textbook than would be feasible otherwise, and permits questions to be directed to interpretation rather than to memory.

Our misgivings with regard to freshmen in the course on Engineering Materials have been shown to be groundless. They learn to read simple equilibrium diagrams readily when they are explained as maps. They can explain from the copper-zinc diagram that a 70–30 brass, when slowly cooled, will be entirely alpha brass, while a 60–40 brass will be a mixture of the alpha and beta prime phases when slowly cooled, but when heated to 453° F. will become a mixture of the alpha and beta phases. They have a fairly good comprehension of the changes which take place in tempering steel and in age-hardening duralumin.

The non-metallic materials used by engineers are worthy of just as careful study as the metals. Portland cement is one of the most important building materials, and much is now known of its structure and properties. Clay products, refractory materials, and glass are certainly worthy of attention. Corrosion is extremely important, and protection from corrosion is equally so. Plastics are so widely publicized that it seems necessary to devote a little attention to them. It is evident that only a most elementary treatment of protective coatings and plastics can be undertaken with

students who have no knowledge of organic chemistry. However, by starting very simply, some knowledge can be imparted.

Fuels and water are certainly engineering materials, and an elementary knowledge of fuels and combustion, and of the softening and purification of water should be given to all engineering students.

Our course in Engineering Materials is still in the evolutionary stage. We have found that freshmen can make satisfactory progress and that they enjoy the work. We believe that all engineering students should study this important subject early in their college course, so that they may have some knowledge of materials before they commence to study structures and machines.

THE CHEMICAL ENGINEER IN NATIONAL DEFENSE*

By STEPHEN L. TYLER

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The events of the very recent past have indicated clearly that we are moving rapidly toward an all-out defense program. There may have been a question a few months ago as to just how far we would have to go with the program originally laid out, but I think I can safely say there is little question today. All of the plant expansions and industry expansions which seemed to run into such fantastic figures may well be needed and perhaps more.

The demands of this program may be divided broadly into three groups. First, men, meaning army and navy personnel. Second, machines, which includes all kinds from shop equipment to large tanks and airplanes, and material of many kinds needed by the armed forces. Third, and last, that group which is of chemical origin and includes explosives, medicinals, petroleum products, and many raw materials for a multitude of manufactures.

It is to the third group that the chemical engineer can make his largest contributions, and for which he is obviously best fitted.

The one industry in this group most greatly affected by the defense program is that producing munitions. The peacetime production of military explosives of all types was relatively small. The daily production of smokeless powder alone must be stepped up from about fifty tons to at least one thousand tons. In order to accomplish this, it is necessary to increase greatly our production capacity for both nitric and sulphuric acids. Fortunately, we are not, as we were in 1914–1918, largely dependent on saltpeter for nitric acid, nor on metallic sulphides to an appreciable extent for our sulphuric acid production. The direct conversion of ammonia to oxides of nitrogen has solved the nitric acid problem, and the increased production of sulphur has kept pace with requirements for sulphuric acid so we are here again self-sufficient and relieved of what would otherwise have been a tremendous problem of transportation. To consider one more military explosive, namely, TNT, we find the situation quite satisfactory. The basis of this is toluol for which we were dependent on the coal tar industry, but recently

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a process has been developed for the synthetic production from petroleum. It is this new source that relieves what might have been a serious shortage. The estimated demand is sixty-five million gallons, and the peace time production was about twenty-five million gallons.

I could go on making similar comparisons for a multitude of chemicals required both directly and indirectly in defense, only to find the situation very much the same in all cases.

I think you will all agree with me that the process mentioned for the greatly increased production of strategic materials has been the result very largely of work done by chemical engineers. The work done in the colleges on the theory connected with unit operations has been the basis of much of the new design work, and has made possible many processes which a few years ago would have been considered as impractical to say the least.

The number of men required to carry on the initial research and development work is only a very limited number compared to those needed to handle the very large problems connected with the design of a commercial plant, its erection, and ultimate operation.

It is quite apparent that a development which has been so dependent upon chemical engineering when commercialized would require large numbers of men with chemical engineering training. The younger men have assisted the more experienced men in the design stages, and have thus become familiar with the plant so as to be valuable men during the construction and initial operation periods. This situation has made possible the very rapid expansion which we have all witnessed during the last few months.

The plants which were designed a few months ago, and have been in the course of erection in the intervening period, are rapidly getting into production, and here the problem is of an entirely different sort. The number of men required to handle the design problems would only be sufficient for the more important staff jobs, and, therefore, we are facing the difficulty of supplying literally large number of men of very much the same type as those who handled the design problems but who now must handle the production. This is a real problem, and the solution is not in sight.

The shortage of chemical engineers and others required for production was anticipated many months ago by industry, by technical societies, and by the Administration of the Selective Service Act. The American Institute of Chemical Engineers has been working very closely with the Administration of the Selective Service Act, and has made surveys in order to truly present the situation. There were many broad statements made without actual

figures to substantiate them, and it did not seem right to continue talking of extreme shortages without proving the statements.

Some of the information obtained by these surveys may well be of interest. On the basis of replies received from seventy-one colleges in which chemical engineering courses were given, we show the total number of men available in June of 1941, 1942, and 1943 as listed in the following table:

	1941	1942	1943
Bachelor's degree in Chemical Engineering	2104	2454	2590
Master's degree in Chemical Engineering	337	325	349
Doctor's degree in Chemical Engineering	87	74	88

These figures indicate that there will be no surplus of chemical engineers but that the problem may not be as serious as has been anticipated, but there are other factors to be considered which reduce the number of men available. Our studies have shown that about two hundred and fifty men are planning to continue their studies for higher degrees. Many of the graduating chemical engineers have Reserve Officer status because of R.O.T.C. work while in college. The men who are placed on the Reserve Officer list are exempt from registration for Selective Service. Therefore they must be placed in an entirely different category. There are 498 such cases. This figure, of course, is an over-all figure, and may be reduced somewhat as certainly not all of the men would be able to pass the physical examination for a Researce Officer rating, and other factors may help to reduce the figure. Assuming, however, that the figure is very nearly correct, we have then nearly 750 of the 2100 immediately removed from the list of those available to industry. This gives a net figure of about 1350.

Obviously this is only one half of the story as the demand on the part of industry must be known before we can reach any conclusion. We, therefore, sent questionnaires to the major companies employing chemical engineers, and to date have received a number of replies, although the returns have by no means been complete.

Our questionnaire was sent to 125 companies, all of whom were known to employ chemical engineers. The twenty-five companies from whom we have received replies employ 42,000 males, of which 737 were chemical engineers. These companies indicated that they would require at least 328 more men with chemical engineering training within the next twelve months. On this basis, there will be a requirement amounting to 44 per cent of the chemical engi-

neers now employed. Now referring back to our survey on supply, we indicated that there would be approximately 1350 men available this June. This figure represents about 44 per cent of about 3100. We certainly agree that there are many more than 3100 chemical engineers already employed. I do not think I need to go further to show definitely that there will be an extreme shortage.

It is quite apparent from these figures that men with only limited training or special training will have to be used in place of completely trained men. We also will have to look to the non-essential industries for some of their employees to be transferred to the important defense industries.

The demands of industry are the major part of the requirements, but various branches of the government need a few men. The needs of the War Department very fortunately are limited, and will probably be taken care of by the reserve. Taking these men, however, in most cases means a loss to industry or education. The Chemical Warfare Reserve Officers have not been called to the same extent as those of other branches of the service. This war so far has not called for gases or chemicals for offense or defense. The Arsenals are being enlarged, and plant is being installed for the production of war gases. About six weeks ago Edgewood Arsenal announced that they wanted to obtain thirty-five chemical engineers for civilian duty. Up to the middle of last week, they had not located their men.

All departments of the Government recognize the fact that skilled or trained men are few as compared to the certain demand. On May 2nd, the President in a letter to the Office of Production Management said, "each man who is subject to Selective Service, and who is capable of working one of these machines should be deferred." He went on to outline plans for the War Department and Selective Service to re-check their lists, and make sure they do not induct into the armed forces men with special skills important to the defense program. Finally, he warned "it will probably be necessary to discharge men who are already in the Army." This all leads up to the one point which I wish to emphasize. If men have been taken into the Army who were on work important to defense, and their services would now be of particular value, they may be demobilized.

The procedure, briefly, is for the previous employer to address a letter to the Adjutant General, Washington, D. C., giving the complete details of the case and requesting the discharge. No selectee will be discharged, however, unless he desires that such action be taken.

There is one more point which I wish to stress, and that is that all chemical engineers should be retained by industry, with the

exception of a few actually needed by the Government. Deferment, and specifically, a classification under Paragraph 2*a*, should be requested. This applies to new employees as well as those who have actually had experience. We can go one step further and say that young men who have just received their Bachelor degrees, but who have not found employment, should request deferment on the basis of potential value.

I have not mentioned the large demand for inspectors by both the War Department and industry. A few chemical engineers may be needed here, but certainly the average man can be of much greater value in actual production.

In closing, I wish to leave these thoughts with you. The young chemical engineer undoubtedly will have the greatest opportunity for success and advancement. Therefore, his instruction should as much as possible be developed with these thoughts always in mind. He should keep in mind that he is a professional man. He should have a strong wish to work amicably with others, be they his superiors, his co-workers, or his subordinates. He must cheerfully undertake every assignment, agreeable or not, with full zeal—particularly *now*.

TEACHING METHODS IN COST CONTROL *

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Meaning of Cost Control.—Cost control is a very comprehensive term. Consequently, when it is used in written or spoken English, it usually does not convey a crystal-clear meaning.

A review of 35 textbooks on cost accounting published during the period 1921 to 1941 reveals no clear-cut definition of the term, cost control, as it is used in this subject. In a few of these textbooks, it is mentioned vaguely, but in the big majority of them it is omitted entirely. In two cost accounting textbooks, however, a description of the term, cost control, is rather definite, as the following quotations indicate. "The word *control* has come to have a . . . new meaning (which) may be referred to as its managerial use; or insomuch as it is employed in connection with the guidance and regulation of the internal operations of a business through up-to-date costing, it may be termed the 'cost analysis' meaning of the word. In this sense it refers particularly to the guidance of business activity through the measuring of manufacturing and sales performance." † Again the term, cost control, is indicated as follows: "Cost accounting is fundamentally a management device. From the cost accounts and other summary records, cost analyses are obtained and presented in report form to the managerial executives. The latter are thereby made acquainted with the internal operating conditions. This, in turn, enables them to comprehend conditions quickly, to formulate policies . . . in order to establish the measurement of and control over the cost of operations." ‡

The most definite and tersest definition, which I have been able to find, however, is as follows: "Cost control (is) the guidance and regulation of the internal operations of a business, by means of

* Presented at the 49th Annual Meeting, S. P. E. E. (Industrial), University of Michigan, June 23–27, 1941.

† Reitell, Charles, and Johnston, C. R., "Cost Accounting, Principles and Methods" (Second Edition), p. 9, International Textbook Company, Scranton, Pa., 1937.

‡ Van Sickle, Clarence L., "Cost Accounting, Fundamentals and Procedures," p. 4, Harper and Brothers, 1938.

modern methods of costing, through the measuring of manufacturing and sales performance." *

The term, cost control, has had two meanings during the evolution of industrial engineering, cost accounting, and industrial management over the past 40 years. The first and older meaning is the mechanical or bookkeeping aspect of cost control. When cost accounting was in its early formative stage (roughly between 1900 and 1920), the term cost control originally referred to the cost control accounts. Raw material, work in process, and finished goods inventory items, plant and service expenses, and units of equipment in detailed auxiliary ledgers, were controlled by their respective general ledger cost control accounts. And this plan is still in effect today in all cost accounting systems.

The second and newer meaning of cost control is the managerial aspect which it conveys. With the advent of scientific management principles, and with the rise and steady development of industrial engineering, cost control has come to have a more comprehensive meaning. This broader meaning of cost control embodies principles, procedures, and policies. It incorporates engineering principles, it utilizes cost accounting procedures, and it aids in developing managerial policies.

With the preceding as a background relative to the meaning of cost control, a new definition is advanced, in a modern sense, as it will be considered in the remainder of this paper. Cost control is the utilization of cost accounting procedures to transmit the result of engineering specifications and factory operations to the executive personnel so as to enable them to comprehend operation conditions, to formulate policies and to check upon the execution of those policies.

With this definition of cost control kept in mind, the teaching methods in connection therewith will be developed accordingly.

Especial attention is called to the natural threefold division of business activity reflected in this new definition, namely, the engineering, the cost accounting, and the executive personnel divisions.

Scope of the Subject.—Teaching methods in cost control embodies three basic factors, as follows:

(1) What to teach in cost control.
(2) When to teach it.
(3) How to teach it.

What to Teach in Cost Control.—As previously indicated, the term, cost control, pertains to industrial engineering principles,

* Jackson, J. Hugh, Underlying Principles of Cost Control, p. 45, National Association of Cost Accountants, 1938 Year Book.

cost accounting procedures, and business policies. Therefore, the teaching of cost control embraces the teaching of all topics within these three fields of activity.

What to teach in cost control also implies why the various phases of cost control should be taught. Both the what and the why of teaching cost control is reflected in the other subject on the program this afternoon, namely, of the Essentials of Cost Control, and they lie without the scope of this paper. A little further on a list of specific subjects comprising cost control, however, are enumerated merely as a basis for developing the teaching methods relative thereto.

When to Teach the Topics in Cost Control.—The second basic factor in the teaching of cost control refers to the order of arrangement in presenting the specific cost control subjects. This factor also relates to the amount of time that should be devoted to each of the subjects, and time is not taken to develop this point.

How to Teach the Subjects in Cost Control.—Frankly, when you are on the program to talk on Teaching Methods in Cost Control to a group of tried and tested veterans in this work, I realize my limitations. You may resent being told how to teach; that is, what methods to use in teaching cost control. This reminds me of a little story that is apropos of this occasion. A prominent business man was approached on the street by a panhandler. The panhandler said: "Mister, will you give me a dollar?" The business man was offended by this insolence, and said to the beggar: "What do you mean by asking me for a dollar? Why didn't you ask me for a dime?" The panhandler replied, "Listen, mister, it is O.K. with me whether or not you give me a dollar, but don't tell me how to run my business."

You gentlemen, too, may resent being told how to run your business; that is, how to teach cost control. And you have a perfect right not to agree with the methods suggested. When I suggest that a particular way is how cost control should be taught, that is the way I think it is best developed. Some other way than that which I suggest may be better for you to develop the same cost control. On the other hand if I may mention a point or two that seems to contain the germ of a good or new idea, then perhaps your time here has been well spent.

Primary Phases of Cost Control.—The scope of cost control, as previously outlined in the new definition, included a range of business activity extending from engineering organization through to general executive policy determination and execution. Each phase or link in this chain of cost control, that extends from its point of origin to its final point of fact presentation, is of equal importance in teaching cost control. This is true because each phase of cost

control next enumerated is directly predicated upon the preceding phase or phases, and therefore, a logical order of presentation is of imperative importance.

The primary phases of cost control are enumerated as follows:

(*A*) The Engineering Foundation Phases of Cost Control.
- (1) Plant design.
- (2) Plant departmentalization.
- (3) Production flow.
- (4) Product design.
- (5) Operation analysis and classification.
- (6) Job and product specifications.
- (7) Tool supervision.
- (8) Equipment control.
- (9) Maintenance control.
- (10) Safety engineering.
- (11) Personnel control.
- (12) Motion and time studies.
- (13) Wage incentives.
- (14) Inventory control.
- (15) Material handling.
- (16) Setting standards.
- (17) Production planning.
- (18) Production control.

(*B*) The Cost Accounting Phases of Cost Control.
- (19) Design and installation or revision of cost accounting system.
- (20) Material accounting.
- (21) Labor accounting.
- (22) Overhead and burden accounting.
- (23) Inventory accounting.
- (24) Production cost analyses and report preparation.
- (25) Marketing cost analyses and report preparation.
- (26) Budgetary control analyses and report preparation.
- (27) Statistical analyses and report preparation.

(*C*) The Executive Utilization Phases of Cost Control.
- (28) Cost report review, policy planning and follow-up of plans.
- (29) Accounting statement review, policy planning, and follow-up of plans.
- (30) Statistical presentation review, policy planning, and follow-up of plans.

The number of courses required to teach these 30 primary phases of cost control varies in different educational institutions. These 30 subjects might be condensed into three courses; they are often expanded into 10 or 12 different courses.

The reason for designating the 30 phases of cost control as the primary phases is that each separate control factor is comprised of numerous subdivisions or topics. For example, production control

is subdivided into the secondary cost control factors of scheduling, dispatching, production order follow-up, inspecting, defective work control, waste reduction, and scrap control. Each of the other primary phases of cost control are comprised of similar sub-divisions.

Cost Control Factors Classified.—The primary phases of cost control previously presented fall naturally in the three fold division suggested in the new definition of cost control.

The first 18 phases of cost control enumerated lie within the domain of the engineering department, principally within the industrial engineering group. These 18 primary phases of cost control represent the foundation of cost control.

The next 9 primary phases of cost control, or items (19) to (27) inclusive represent the jurisdiction of control exercised by the cost accounting department. These 9 phases of cost control represent the communication line from the industrial engineering control to the executive personnel control.

The last 3 primary phases of cost control constitute the focal point of cost control. These 3 phases represent the province of the departmental and divisional administrative executives of the business. They represent the pinnacle point in cost control. That is, at this point, the utilization of cost analyses, reports and statements by the executive group is for the purpose of controlling incomes, costs and expenses to insure the earning of a proper return in relation to the capital invested.

In this classification, there is seen clearly the relationship between and among the threefold groups in cost control. The industrial engineer plans and supervises the production activities. The cost accountant accumulates, analyzes, synthesizes and presents the results of the production and marketing activities. The executive peruses the cost reports, accounting statements and statistical analyses in order to become acquainted with the maze of details reported upon and to formulate their policies therefrom.

The purpose of the preceding control classification is also to outline more succinctly the problems involved in the teaching methods in cost control.

Difficulties Involved in Teaching Cost Control.—Numerous difficulties are encountered in teaching cost control. One of the principal difficulties is the diversifications embodied in this broad subject. The threefold division of business activity which is reflected in the 30 primary factors of cost control and their numerous subdivisions, represents an enormous mass of principles, fundamentals, and details. The development of the subject matter which comprises industrial engineering and cost accounting presents a problem difficult enough within itself. Yet, this is not the only prob-

lem which faces the instructor who must teach cost control. If he is to do the job in the best possible manner and for the most beneficial interest of the students, then the instructor must weave in additional aspects of the industrial concern along with the technical aspects of industrial engineering and cost accounting. Cost control is inseparately related to and influenced by other allied fields such as economics, marketing, statistics, general accounting and business policy. The teaching of cost control is a real challenge to any instructor. To meet this challenge, the instructor must have not only a thorough understanding of the two basic fields in which cost control is centered, that is, in industrial engineering and cost accounting, but he must know how to inter-weave those pertinent portions of these other allied fields into the cost control picture.

Then, as if the preceding teaching difficulty is not a sufficiently staggering problem, it may, and usually is, magnified by the make-up of the class that is being taught the essentials of cost control.

If the class is made up exclusively of engineering students, then the teaching emphasis must center upon the cost accounting and business policy factors, in order to acquaint this group with the tool (cost accounting) used for reporting, and the use made of the reports in cost control. If the class comprises business administration students only, then the teaching emphasis should be placed upon the industrial engineering cost control factors, in order to acquaint the students with the foundation factors of technique (the primary phases previously mentioned, (1) to (18) inclusive) in cost control. If the class includes both engineering and business administration students, then the instructional problem is again something to conjure with. Under this last circumstance, the instructor is faced with the necessity of using a fine sense of balance. He must develop the industrial engineering cost control factors (the foundation techniques) to the business administration student, and he must present the cost accounting control factors to the engineering student in such a manner so as not to bore each of the other respective groups with subject matter about which they are already quite familiar.

Approach to the Methods of Teaching Cost Control.—From this point on, there are two avenues of approach which may be followed in developing this subject. First, the teaching methods of specific controls may be elaborated upon, in detail, so as to cover only a few subjects, as for example, setting standards, production planning and control, overhead and burden accounting, etc. Second, the teaching methods of cost control may be developed in a broader manner, so as to cover the entire field in a general way.

If the first approach were used, then the question is immediately raised as to what are the most important specific cost controls

that should be chosen and elaborated upon. If this question were to be decided, then the problem of dogmatic treatment, from one person's point of view, becomes a moot question with respect to its real value.

Realizing the limitations that are imposed by the subject of this talk, then the second of the two approaches with respect to methods in teaching cost control is followed. Even in following this general approach, the teaching methods as conceived by one person, cannot be considered as a prescription, a formula or a pattern to be followed religiously by all others. The teaching methods enumerated and described here are merely considered as suggestions.

There are eleven different major methods of approach in teaching cost control. They are as follows: Organizing the class; Plant visitations; Motion pictures; Lectures; Recitations; Supplementary assigned readings; Conferences and seminars; Special reports; Problems; Laboratory sessions; Coöperative work.

Organizing the Class.—At the first class session, the students should be apprised of the manner in which the class will be conducted. This should include what the instructor expects of the students in the course in the way of study and classroom work. The general nature of the course should be outlined, and the student should be informed how the specific cost control course relates to other aspects of cost control in other courses.

Other principal, pertinent points that should be brought to the attention of the students, at the first meeting of the class, are those attributes which will tend to make the student more successful while in college and after he graduates. These attributes are personality, the use of written and spoken English, inquisitiveness, imagination, technical perfection and the need for accuracy.

Purpose of Plant Visitations.—The purpose of this method of teaching in cost control is to acquaint the student with the physical operation of a plant. Many students who take courses in cost control have never visited an industrial plant. Consequently, when such cost controls as plant layout, departmentalization, production flow, manual and machine operations, etc., are mentioned in class, the terms are either meaningless or vaguely understood by the student. After three or four trips have been made to different industrial concerns, then lectures, reading assignments, recitations and even problems on cost control are more comprehensible.

Plant visitations should be made soon after the first courses in cost control have been inaugurated, in order to pave the way for a better understanding in cost control study by the other teaching methods.

The instructor should contact the proper persons at the plants preceding the trip and inform them what he should like to have

the student body see on their trip. If this is done, then no time will be wasted by the plant employees. And the students will be made definitely acquainted with what is to be seen as the purpose for which the trip is made.

The instructor should relate to the students, prior to making the plant visitation, the specific phases of cost control that should be observed. At the next meeting of the class, following each plant visitation, the instructor should lead the discussion of what was pertinent with respect to the different phases of cost control observed in the plant.

Purpose of Motion Pictures.—This visual education method of teaching certain aspects of cost control serves two principal purposes.

First, it is an invaluable substitute for plant visitations where there are no plants located hereby so that trips can be made conveniently.

Second, this method serves as a review of the plant visitation. The instructor can point out the important aspects of the trips which have been previously made.

Purpose of Lectures.—The lecture can be a vital force in teaching cost control, but to be effective it must be employed at the proper time and in the right proportion in relation to the other teaching methods. The lecture can be utilized effectively as follows:

(1) To introduce new topics in the different phases of cost control.
(2) To stress the most important aspects of new topics in the different phases of cost control.
(3) To explain the difficult features of the new topics developed under the different phases of cost control.

Except for these three different uses, the lecture should be used sparingly. Students should be taught to reason, to think, and to develop their imagination. These three attributes, combined, weigh heavily in the total attributes that make for the success of a student after graduation. The lecture is not the method that usually develops these attributes most successfully.

The use of slides, projecting machines, motion pictures, and sample forms are auxiliary aids in making lectures more interesting and more informative.

In some schools, the practice is to invite visiting lecturers to talk on specialized topics or specific phases of cost control. This plan has merit in that it brings to the class a different viewpoint, with full emphasis on the practical application, as compared with the presentation by the regular instructor. The fault of this method

usually lies in the presentation of the special lecturer. He usually is an outstanding engineer, accountant or business executive in his own respective field of special work, but not being accustomed to classroom instructional methods, he often falls flat in his presentation. He often rambles from the subject, fails to follow a logical order of presentation, lacks ability as a public speaker, or talks "over the heads" of the students. A visiting lecturer, who is an outstanding authority in his field, and who possesses the ability to present his subject in a good academic fashion, however, is a real asset. He provides a change of pace in the instructional routine of the regular instructor.

Purpose of Recitations.—The recitation is probably the most commonly used method of teaching cost control with the possible exception of problems.

Since the recitation is invariably based upon assigned readings in the textbook, which has been chosen for the particular course in cost control, it constitutes one of the most important principal units in the planned program of study. The cost control topics are arranged usually in logical order in the textbook, and its perusal by the student helps to fix the fundamentals of the cost control subject in his mind. If the textbook does not provide a list of questions pertaining to each chapter, the instructor should select the pertinent points from each chapter as a basis for leading the class discussion. The greatest value that arises from the recitation is the discussion that results therefrom. Often there are certain facts which are not clear to the student, which will be cleared up by the classroom discussion developed by the students' recitations and the instructor's comments.

Students should be cultivated, by the instructor, to think through difficult aspects of cost control factors, to reason out correct answers, and to imagine circumstances and conditions about which they are not entirely familiar. Never tell the student that a subject is difficult, because it often creates an inhibition on the part of the student toward study.

It is through the recitation that the instructor has innumerable possibilities for developing the student. During the recitation the instructor should develop not only the student's interest in and ability to comprehend the subject matter, but he should be on the lookout secondarily for other weaknesses in his students. This is just as much of a responsibility of the instructor as it is for him to teach the fundamentals and techniques of any cost control topic. One of the chief weaknesses of students is their inability to make a recitation straightforwardly in keeping with all of the tenets of good speech. A prominent man in the field of English has said that:

"One who cannot express himself well does not know definitely what he is talking about." The graduating student today cannot go far without being equipped with the ability to speak English grammatically correct. Shyness which is often evidenced also in the recitation can often be cultivated into an air of assuredness by a paternalistic interest on the part of the instructor. Speech should be a required course.

The Purpose of Supplementary Assigned Readings.—The purpose of this method of teaching cost control is fourfold, as follows:

(1) To provide for reading assignments to cover topical details not mentioned or sufficiently covered in the textbook used in the course.
(2) To study in greater detail those primary phases of cost control, which are not an integral part of the specific course being taught.
(3) To furnish a different viewpoint of the subject matter being studied in the specific course.
(4) To develop the research attitude and viewpoint in the mind of the student.

If an adequate library is available in the field of cost control, then it should be utilized fully and frequently. If the instruction to the student consists of lectures, and recitations only from the course textbook, then the course has a tendency to become provincial instead of broadening.

The instructor should make assigned readings in selected textbooks and technical magazines and journals. The student should be required either to write an outline brief of the assignment, or to make a short verbal report thereon. The undergraduate student may think that this assignment is a real hardship in addition to all of his other work, but he should be impressed with the importance of developing a breadth of vision and understanding of the subject matter in cost control.

Purpose of Conferences and Seminars.—The purpose of conferences, as a teaching method in cost control, is to clarify topics and problems which are baffling to the student. It depends upon the individual instructor as to the manner in which this method is applied. Some instructors sense the fact that some students need personal aid, more detailed explanations and a word of encouragement, and accordingly invite such students to their office for a personal conference. Other instructors believe that the student should take the initiative, if they need personal help, and ask for an appointment for a private conference.

Under all circumstances, it must be considered an accepted fact,

that there are always certain students who are in need of personal aid in teaching cost control to them.

The purpose of seminars, as a teaching method in cost control, is reserved for classes which are conducted on a graduate scale. The seminar class offers one of the best methods of instruction in teaching a selected group of students. The student's research problems and projects are worked out with a fuller understanding on their part under this method of instruction. The instructor should and usually is able to develop in the student, by this method of teaching, a spark of enthusiasm that is far greater than it is possible to develop by any other method of teaching. In the seminar class, the instructor literally puts at the disposal of the select students the wealth of his knowledge and experience pertaining to the subject matter. The instructor should make the student feel at perfect ease in his presence. The instructor should also encourage the student to develop an inquisitiveness relative to the subject matter that will kindle a lasting interest in cost control. The reward to the instructor for this intensified personal interest that is taken in the student is the top-most success which ultimately comes to the majority of students who have been under his tutorage.

Purpose of Special Reports.—The purpose of the special report as a teaching method in cost control, is fourfold as follows:

(1) To provide a plan for a more extensive point of view and breadth of knowledge.
(2) To study in greater detail those primary phases of cost control, which are not an integral part of the immediate course being taught.
(3) To develop research study and technique.
(4) To perfect the students training in report writing.

There are three different classifications of special reports, as follows:

(1) The short report on a single specific topic that comprises a part of some primary phase of cost control.
(2) The term project that embodies several topics that represent some complete primary phase of cost control.
(3) The course thesis that embraces some combination of the primary phases of cost control.

The short report, that covers only a single specific topic, may be written in conjunction with supplementary assigned readings. Obviously, the most important topics of the particular course in cost control should be assigned for the short report. Each student in the course should be given a list of the topics to be reported upon, and permitted to make his own choice as the topics appeal to him.

The title of the term project, as a more comprehensive piece of research, may be chosen by the student, subject to the correction and revision by the instructor. The student should be counselled on the term project several times, during its preparation, by the instructor.

The subject for the course thesis, as the most comprehensive piece of research, may be chosen by either the instructor or by the student. After the subject is chosen, the method of procedure to be followed in the research should be specified by the instructor. The student should report to the instructor on a regular time schedule basis for the purpose of counselling. A comprehensive outline should be prepared by the student and submitted to the instructor for review and suggestions.

In all three types of special reports, the instructor should be on the lookout for two things in particular. First, he should check carefully the correct technical development of the subject matter. Second, he should review critically the failure of the student to adhere to all of the proper rules of good written English. The instructor in cost control subjects may entertain the attitude that English is without the scope of his jurisdiction; that the existence of poor grammar and misspelled words in a report is just the student's own misfortune. Nevertheless, it *is* the responsibility of the instructor in cost control to point out mistakes in written English, in the special reports, if the student is to improve progressively in his chosen field of study.

Purpose of Problems.—The use of problems is one of the most important methods of teaching cost control, if not *the* most important. Certainly to the undergraduate student, who is studying the cost accounting phases of cost control, the use of problems is of equal importance to the recitation. Without problems, to accompany the textbook assignments, the student fails to comprehend clearly the cost control interrelations and the subject matter of the course as a whole.

The primary purpose of cost accounting problems, in teaching cost control, is to develop the theories, techniques, and procedures involved in bridging the gap from the engineering foundation phases of cost control to the general executives' utilization of the information provided in analyses, cost reports, and accounting statements.

Problems in cost control consist basically of two types, as follows:

(1) The specific topic problems.
(2) The combination of specific topic problems into a related project, and into practice sets.

The specific topic problems are required to develop an understanding of cost control from a mechanical or technical viewpoint. Specific problems should be assigned to cover such topics, for example, as follows:

(1) Relating general accounting and cost accounting.
(2) Handling inventory records, raw material costs, defective work and spoilage costs.
(3) Preparing payrolls and labor cost analyses.
(4) Analyzing, assembling, distributing and controlling plant and service expenses.
(5) Computing burden rates and applying them to the jobs and products manufactured.
(6) Compiling the reasons for and the cost of idle plant time.
(7) Building budgets and preparing budget reports.
(8) Ascertaining cost variances.
(9) Preparing cost reports, analyses and accounting statements.

The combination of numerous specific cost accounting problems into practice sets, as a course requirement, is comparable to working a jig-saw puzzle. The specific cost control factors, such as cost orders, cost centers, cost operations, cost elements, production planning factors, production control factors, etc., are the parts of the puzzle or the component elements of the complete practice set. When they are assembled as a complete problem covering a summary of one months' operations of an industrial concern, then the student can see clearly the component parts of cost control as a complete picture.

In order to make the practice set more realistic, this type of problem should represent some specific industrial concern. A greater interest is evidenced by the student when he is working up the unit and job costs of glassware, steel plates, coke and its by-products, gears and pinions, etc., than when the production in the problem consists only of fictitious products.

Purpose of Laboratory Sessions.—The purpose of the laboratory session, as a teaching method in cost control, is a fourfold one, as follows:

(1) To enable the instructor to become better acquainted personally with his students.
(2) To lend aid personally to students who are experiencing particular difficulty with certain cost control topics.
(3) To guide students through the maze of cost control details.
(4) To give students the "feel" of cost control procedures that will be encountered in actual practice.

Many of the engineering foundation phases of cost control are developed best within the laboratory. This includes such primary phases of cost control as production flow, product design, operation analysis and classification, motion and time studies, setting standards, production planning and production control.

The cost accounting phases of cost control which are best developed in the laboratory, are as follows: computing predetermined burden rates, building budgets, preparing detailed cost analyses and reports, and working on cost practice sets.

Purpose of Coöperative Work.—Where it is possible to provide coöperative work in with the cost control curriculum, it provides an ideal plan for student instruction. This holds true particularly for the engineering major students. It is an ideal plan for the business administration students majoring in accounting, but it is more difficult to place students in cost accounting work under a cooperative plan than it is to place engineering students in the engineering field of coöperative work.

The particular advantages that arise from coöperative plan of instruction in cost control are that it provides for:

(1) A plan to acquaint the students with practicable procedures in actual practice.
(2) An accumulation of actual shop and factory practices which can be brought back to the classroom from year to year, which are invaluable in pursuing further studies in other cost control courses.
(3) A smoother transition from classroom work, which deals primarily with theories, principles and fundamentals, to actual employment of the student upon graduation.

Who is Best Qualified to Teach Cost Control?—In order to answer this question, it is logical to assume that the specialist in each of the three fields of cost control is the one best qualified to teach his respective subject matter. The industrial engineer can teach best the engineering foundation phases of cost control. The cost accountant is best prepared to teach the cost aspects of cost control. The best qualified person to teach the executive utilization of cost control is the successful retired business man, if such a man can be found who is interested in teaching, and if the educational institution can pay him his price and still balance its budget.

Generally, however, the executive utilization phases of cost control must be developed as a business policy phase of cost control and as a cap-stone to the cost accounting course.

In some educational institutions the industrial engineer is required to teach the cost accounting aspects of cost control. In this event, the engineer should have supplemented his technical engi-

neering training with a study of cost accounting, economic principles, statistics, marketing, and budgetary control.

In other institutions, the instructor in cost accounting must develop the fundamentals of the engineering foundation phases of cost control. Where this condition exists, then the accountant should supplement his training with courses in industrial management, motion and time studies, and production planning and control.

It is a conceded fact that the best cost accountant is an engineer or an accountant who knows thoroughly the production problems and processes of the company for which he works. It is also an accepted fact that the best industrial engineer is one who is thoroughly familiar also with the different fields of business and their interrelated problems.

The instructor in industrial engineering and the cost accounting both must be familiar with the teaching problems of the other respectively. Both must also be familiar with the problems and the nature of the content of the courses taught by the other one respectively, if they are to teach their own respective subjects most effectively and in the best interests of their students. The instructor who has a good sense of humor, who is a good disciplinarian yet not a crank, and who takes an interest in the personal problems of his students is the instructor who will be able to develop the students to the highest degree. The majority of students will usually give all they have to an instructor that they like and respect.

Finally, whoever the instructor may be, engineer, accountant, or business policy teacher, he should be able to kindle the fire of interest in the many topics that comprise cost control. How this interest is developed is a specific and personal problem in the case of each instructor. The cardinal features of being successful along this line is, of course, for the instructor to have next to an unlimited knowledge of the subject matter himself. To possess a thorough knowledge of the subject matter is to disclose a confidence to the student of the instructor's ability. The presence of this condition is easily sensed by the student, and it tends to become contagious. The student will try to emulate a leader, and thereby he acquires a more intense interest in the cost control courses where a leader-type of instructor is present. Perhaps you will think that such an individual who has been described as best qualified to teach cost control, in all of its aspects, is someone omnipotent, a super-man, or maybe a myth. Nevertheless, these are the qualifications to possess in order to be a successful teacher. If you and I do not have them, then let us make a sincere effort to acquire them.

TEACHING ENGINEERING ECONOMY TO ENGINEERING GRADUATES IN INDUSTRY *

By DOUGLAS F. MINER

George Westinghouse Professor of Engineering,
Carnegie Institute of Technology

"Cost-consciousness" is a required attribute for engineers engaged in industrial work. Many men now graduating from schools have received some training in the field of Engineering Economy, but many others do not have the opportunity in their chosen curricula to study this subject. Any proficiency in this respect then has to come more or less intuitively or from study undertaken after graduation. To fill this need among engineering graduates and also men of other training who find their work involves economic principles related to technical subjects, the work to be described was organized.

Under present emergency conditions, when we are in the midst of an all-out industrial effort in defense production, it might be said that we are no longer concerned with cost. Considering the almost astronomical appropriations being authorized daily, it might seem money-cost is beside the point. But in a broad sense, cost is not expressed in money alone. In our present program other types of cost are vitally important. Time, tool equipment, materials must be used to the last degree of effectiveness. The teachings of Engineering Economy can point the way in each of these. Planning to save valuable time, selection of fabricating methods to make best use of available machine tools and choice of materials to avoid bottle necks can all come within the sphere of application of Engineering Economy.

The incentive present with students already working in industry is admittedly different from the immediate objectives of college students. The college student pursues a course, acquires recorded knowledge and problem practice with a view to later sorting and sifting the information when he comes to need it. The graduate at work has found in his day's work, problems which he is handicapped in solving, or solves by some rule of thumb or intelligent "guestimate." He then approaches the work in a course on Engineering Economy with a desire for the answers to specific ques-

* Presented at the 49th Annual Meeting, S. P. E. E. (Engineering Economy), University of Michigan, June 23–27, 1941.

tions. Concurrently his understanding of the method, tools and language of industry permit him to grasp more involved problem solutions than those adapted to undergraduates. His attitude is utilitarian or vocational rather than academic. Any course given, then, is adjusted to this situation and can be quite specific. If a given class is drawn from employees all engaged in the manufacture of a certain type of product, the problems and illustrations can be taken directly from that environment.

A word may be said about the origin of the course to be described. In the April 1937, issue of *Electrical Engineering*, Mr. Hellmund, chief engineer of the Westinghouse Electric and Manufacturing Company, presented a paper entitled "A Suggested Course on Industrial Economics and Business Methods." He aimed at a course to be given in engineering colleges and proposed many departures from existing outlines. To find out whether the ideas proposed were useful, Mr. Hellmund asked the author to organize a course and try it out on employees of the Westinghouse Co., first at the East Pittsburgh plant and later at three others. If the plan was successful with graduates, then perhaps there would be merit in suggesting use of certain features in engineering colleges.

Mr. Hellmund, who has long been active in the training of young engineers, worked out in his paper a detailed plan of subject matter and references which is of great value. Some of his principles may be recalled here. First we must understand the economic problems of the "user" of goods. He is confronted by the questions, "shall I buy at all," "shall I buy now," "shall I buy this article or something quite different." Entering these questions are the factors of first cost, maintenance, interest charges, quality vs. price, and scrap value. After understanding the buyer side of the argument (and we are all buyers at some time), we are ready to consider the second phase, the economy of the "supplier" of goods. In most cases of manufacturing ventures it is not possible to figure total cost, add a good profit and charge that to the customer. Often the range of prices (except on new or luxury products) is fixed by market conditions or the limit of customer desire and what we must find out is whether goods can be made for enough under the price obtainable to provide a profit. The subheads given in this field are (*a*) direct labor; (*b*) organization and management; (*c*) works overhead; (*d*) material costs; (*e*) test and inspection; (*f*) design, development and tool costs; (*g*) distribution costs; (*h*) installation and service costs.

In preparing a course, embodying the essentials of Mr. Hellmund's suggestions, a combination of textbook instruction and

lectures on specific subjects by specialists was developed. Grant's "Principles of Engineering Economy" was selected as a foundation text which proved well adapted to the scope of the course. While it was apparently elementary for some who were irked at going through the motions of using interest tables and their variations, this book was a discovery to others and gave them a basis on which to build their economic thinking. The use of a text furnishes an integrating core to which special topics can be related.

After trial and gauging of response, certain topics outside the text were adopted as most useful to the classes being taught. Originally planned for engineering graduates only, the classes soon contained other people who had a direct interest in the subject because of their daily work. Inspectors, time study men, cost accountants and advanced draftsmen were admitted and turned out to be satisfactory students. Men from 22 to 50 years of age attended the classes so that a variety of aptitudes was encountered.

The subjects outside of the text were inserted in the schedule at convenient points, sometimes adjacent to related text material. Sequential arrangement was not always used however, since one objective was to spread these specialized topics throughout the program, providing a change from text discussions in the form of definite information (sometimes illustrative of principles in the text) about the daily environment of the students. Each of these topics was presented by a man experienced in that field, usually a company official whose experience would make his comments and illustrations authoritative.

The course was planned for one two-hour session per week for 32 weeks. When given in East Pittsburgh, the course was coordinated with the University of Pittsburgh-Westinghouse Graduate Program and credit toward a master's degree could be obtained. An outline of the subjects by class sessions follows:

OUTLINE—*First Semester*

(Chapter numbers refer to Grant's "Principles of Engineering Economy")

* Material presented by Westinghouse lecturers.

1. Hunch Decisions are Dangerous.
   Business Decisions are between Alternatives. } Chapters 1, 2.
2. Pattern for Engineering Economy Studies. Chapter 3.
3. Equivalence and Interest Formulas. Chapters 4, 5.
4. Solving Interest Problems.
   Why Interest. } Chapters 6, 7.

*5. Economics of Organization and Personnel.

6. Capital Recovery with Return as Element in Annual Cost. Chapter 8.
   Present Worth: Capitalized Cost. Chapter 9.
7. Calculating a Prospective Rate of Return.
   Economy Studies for Proposed New Enterprise. } Chapters 10, 11.
*8. Statistical Methods and Presentation of Data.
*9. Application of Statistical Methods to Quality Control—Inspection Economics.
10. The Influence of Economy Studies of Sources of Investment Funds. Chapter 12.
11. Comparing Alternatives in a Going Concern. Increments, Costs, and Sunk Costs. Chapter 13.
*12. Functions of Financial Control and Corporation Accounting.
13. Will it Pay to Replace a Machine or Structure. Chapters 14, 15.
*14. Budget Control.
*15. Manufacturing Equipment and Tools—Effect on Costs.
16. Depreciation. Chapter 16.

OUTLINE—*Second Semester*

17. Break-even Points and Minimum Cost Points. Chapter 17.
*18. Selection of Methods of Manufacturing.
19. Capacity and Load Factor.
    Planning for Growth. } Chapters 18, 19.
*20. Function of Time and Motion Study.
*21. Overhead and Expense Control.
*22. Production Planning and Stock Control.
*23. Standardization, Principles and Methods.
*24. Westinghouse Standardization Practice, Preferred Numbers.
*25. Economics of Size and Rating Selection—Engineering Design.
*26. Economics of Material Selection and Use.
*27. Labor as an Economic Problem for the Engineer.
*28. Patents and Copyrights as Economic Values.
29. Engineering Reports and Budgets. Chapter 23.
*30. Distribution Economics.
*31. Servicing of Durable and Consumer Goods.
*32. Report on Collateral Reading.

Some further amplification of a few of the topics will show the type of organization of material which was worked out for each. Under the heading of *materials*, for example, actual figures of material cost content of various products were studied and also the relation of investment in equipment to labor and material costs. Example figures are the following:

DIVISION OF FACTORY COST BY PERCENTAGE

Product	Labor	Material	Expense
Instruments	30	36	34
Stokers	29.5	41.5	29
Heavy electrical machinery	24.1	45.9	30
Small motored appliances	22.9	44.6	32.5
Steam equipment	20.6	44.4	35
Lighting equipment	18.2	53.9	27.9
Gears	18.5	51	30.5
Appliances	18.2	57.4	24.4
Porcelain	16.2	55.9	27.9
Transformers	14.6	64.8	20.6
Average of all products	21.9	51	27.1

Another economic aspect of materials emphasized is the preparation of adequate yet not too rigid purchasing specifications. A specification must provide a description of what is wanted, determine the performance or properties, limit the dimensions and tolerances, name the tests to be made, describe the method of marking, packaging and shipping, and define the conditions for rejection.

Standardization, whether of materials, methods of fabrication or completed product is a highly vital subject. We recognize the need of standards in screw threads, hose couplings, track gauges and shirt sizes, but forget that the advantage of standardization may be lost sight of in refrigerators, housing or books. Low cost, availability, interchangeability, all follow attainment of national standardization. Enormous savings have been made by eliminating unnecessary sizes and grades. Materials standards may be achieved by following certain principles. Guiding principles for standardization of materials were presented in the following form:

In general, material standards must be governed by design requirements, and economics. This requires:

1. Sufficient variety (grades) and sizes available to accomplish the engineering result.

2. Avoiding too many grades and sizes because this increases costs (purchasing, stores, obsolete stocks, records) and leads to confusion and multiplicity of records.

3. Avoiding too few grades and sizes because this frequently leads to the use of too expensive grades (when intermediate quality is not made available) and too large a size (when intermediate size is not made available).

4. Rational selection of grades and sizes to provide sufficient range of quality and quantity in economical steps, avoiding of grades or sizes too close together.

5. Standards selected in line with national or trade practice to provide minimum cost and maximum availability.

6. Standards coördinated between plants to provide for exchange of stocks or to prevent trouble in moving activity from one plant to another.

7. Adequate information furnished to all departments on standard materials.

This aids the proper selection of the available materials.

Most of the students in Engineering Economy were not primarily concerned with finance, but an understanding of the methods of conducting a company's business enables them to appreciate the problems involved and what their engineering decisions entail in new expenditures for plant and equipment, and what costs of obsolescence are incurred by new or changed products. It is a surprise to many students to learn of the wide variety of functions of the financial departments grouped under the comptroller. It is explained that accounting has two purposes. The first is to assure that the financial statements to stockholders and to governmental agencies properly reflect the earnings and condition of the company. The second is a part of internal operations and supplies information for the guidance of the management. A list of functions of the accounting organization might look like this: time keeping, payroll (hourly) calculations, costing, accounts payable, invoice, accounts receivable, claims, employes' accounts (salary roll), inventory control, taxes, property accounts, social security, statement work, independent audit, annual report, report to Securities and Exchange Commission, systems studies, budgetary control, forecasts, appropriations, internal audit, sales record, purchase records.

Many of the problems for the course were taken from Grant's "Problem Supplement," especially those related to manufacturing subjects. Some examples of other problems are given in the Appendix. Under the subject of Time and Motion Study, the regular forms used in the plant were distributed and the student asked to make a study and proposed improvement of any operation, industrial or otherwise, with which he was familiar. Some mirth developed when one student compared shaving with brush, lather and safety razor against using an electric razor. Another improved (temporarily at least) his wife's bed-making time by 25 per cent.

It is obvious that exhaustive treatment of any of the several subjects is impossible in the time allotted to the course and the whole program may seem like a speedily-conducted tour through Industrial Engineering. One of the aims of the course was to acquaint the student with the economic factors and the functions of various parts of the company by which he was employed and

show him how his own work was dependent on these other elements. It was the hope that sufficient interest would be aroused to stimulate continued study. Student reaction to the course seemed to justify this hope.

Appendix

* Numbers refer to course outline schedule. Pp. 176–177.

Syllabus of Special Topics

*5. *Economics of Organization and Personnel.*
Requirements for effectiveness.
Size and type of units.
Unit integration.
Location and relation of functional activities.
Development of modern organization.
Management problems and adjustment.
Westinghouse growth and history
Westinghouse organization.
Scope and functions of Industrial Relations.

8. *Statistical Methods.*
Variables.
Probability.
Control and lack of control.
Sampling.
Calculations.
Deviation.
Control Charts.
Examples of application to Quality control.

9. *Economics of Inspection* (what to inspect, how much and how often).
a. Durable goods.
Relation of inspection to manufacturing, to engineering, to customer.
Causes of defects.
Intermediate inspection.
Raw material inspection.
Regulation of amount of inspection.
Costs and economic balance.
Tools and equipment for inspection.
b. Consumer goods.
Inspection methods and records.
Feeder and finished product inspection.
Inspection laboratories and equipment.
Spot inspection and independent quality control.
Field records.

12. *Financial Control.*
Handling of credit problems.
Cash reserves.

Financing of material purchases and payrolls.
Taxes and their complexity.
Assets.
Use of common stock, preferred stock, and bonds.
Banking connections—borrowing.
Distribution of deposits.
Reserves for depreciation.
Capitalizing expenditures vs. absorbing in current expense.

14. *Budget Control.*
Purpose of budget.
Principles of budget control.
Flexibility.
Balance between divisions of a company.
Appropriations and schedules.
Relation of budget to volume and profits.
Budget planning.
Statements, their content, use and interpretation.

15. *Equipment.*
Investment of Westinghouse in machine tools.
Equipment cost for different products.
Types of machine tools, and relative costs.
Progress made in machine output and automatic features.
Combination purpose machines.
Design and construction of process equipment.
The Manufacturing Engineer.
Load factor on expensive equipment.
Machine cost vs. hand labor cost per piece with different activities.
Obsolescence, depreciation rates.
Amortizing cost of new equipment.
When should machine tools be retired?
Undepreciated value.
Maintenance equalization.

18. *Choice of Manufacturing Methods.*
Relation of process to cost analysis and time study.
Cost Reduction and Methods of Analysis.
Evaluation of alternative methods of making a device.
Methods as related to activity.

20. *Time and Motion Study.*
Evolution of the art.
Why needed.
What can be accomplished?
Methods of obtaining basic data.
Auxiliaries such as movies, instruments, etc.
Development and use of formulæ.
Human problems involved in applying limits.
Case histories of products analyzed.

21. *Overhead and Expense.*
Cost centers.
Relation of expense to labor.
Content of expense.
Expense factors or ratios.
Control of expense.
Distribution of expense to groups, machines or departments.
Prorated expenses—why necessary, how controlled.
Relation of expense factors to volume.
Volume, labor and material variances.
Standard cost.
Costs of products made in one plant and used in another.

22. *Production Planning.*
Elements of production—men, materials and machines.
Ordering materials.
Machine loading.
Set-ups.
Grouping work.
Work in progress.
Production charts.
Production planning and control.
Order handling.
Promises, deliveries.
Coördination and expediting.

Control of stocks of parts and products.
Inventories.
Part stocks.
Forecasting.
Economic quantities for stock.
Warehouse locations and problems.
Disposition of stock.
Obsolescence.
Ordering from stock—order handling.

23. *Standardization.*
Principles of standardization.
Importance of economics in engineering.
Division between economics of consuming and producing.
Place of standards in living.
Definition of standards—*e.g.* flexible strictness.
Need of industrial standards.
Types of standardization.
Application of standards.
Standardizing agencies.

24. *Westinghouse Standardization and Preferred Numbers.*
Standardization of materials, systems, parts, designs.
Control and information on standards.

Examples from Standards Books.
Savings and other advantages of Westinghouse standards.
Origin and basis of preferred numbers.
Reason and value of preferred numbers.
Methods and rules of use.
Westinghouse uses of preferred numbers.

25. * Economics of Sizes and Ratings—Engineering Design.
Application of preferred numbers.
Graphic representation of size selection.
Costs related to size.
Excess costs.
Calculation of constants.
Minimum cost.
Efficiency and performance, influence on size.
Coördinating design of a line of products.
Standard parts and sub-assemblies.
Development planning—long and short range.
Following trends—customer demand.
Effect of activity on design methods.

26. *Economics of Materials.*
Material content in electrical apparatus.
Types of materials.
Purchases.
Specification system.
Choice of materials.
Information on materials.
Establishing standard grades of materials.
Substitutions.
Economic changes in market and trends of materials.
Cost reduction by materials—saving results.
What price quality.
Cheaper and better.

27. *Labor as an Economic Problem for the Engineer.*
Cost of labor as part of the product cost.
Variation with type of product.
Determination of what labor costs are permissible.
Productivity of labor.
What is a fair wage.
Incentives, wage payment systems, bonuses, profit sharing.
Labor market and plant locations.
Competition as affected by labor costs.
Stimulation of mechanication by rising labor costs, lack of trained labor and by attitude of labor.

* Based on paper by R. E. Hellmund, Product Engineering, September, 1932.

28. *Patent Values.*
Method of handling patents.
Fundamentals of patent law.
Difference between foreign and American patent practice.
What is patentable?
Patentability of substitutions, combinations.
Disclosure information—dates, witnesses, evidence, interference, etc.
Wording of claims.
Joint inventors.
Re-issues.
Patent values as a company asset.
Protection of development and invention.
Process patents.
Copyrights and trade-marks—where used, value and procedure.

30. *Distribution of goods.*
Methods of selling dependent on product.
Advertising policies and sales promotion work.
Costs of distribution related to factory cost.
Study of markets.
Influence of competition.
Pricing policies and methods.
Marketing of technical products to ultimate user.
Types of customers (syndicate, small manufacturer, utilities, government, individuals) and how they are contacted.
Dealers, jobbers, contractors.

31. *Installation and Servicing.*
a. Durable goods.
Handling construction and installation.
Costs in field compared to factory.
Adaptation of methods to needs of job.
Emergencies and breakdown.
Field development and field adjustment.
Influence of service experience on design.
Repairs.
Strategic location of service shops.
Guarantees and company responsibility.
b. Consumer goods.
Installation and servicing costs—equipment and personnel.
Field troubles and their correction.
Influence of field experience on design, manufacturing and inspection.
Customer whims and needs.
Difference between industrial and individual customers.

PROBLEMS

A. Labor as an Economic Problem.
You are managing the principal factory in a town and employing 1000 people at an average of 75¢/hr., 40 hr./week, 50 weeks/year. You

have been doing a business of $5,000,000/yr. and losing $500,000/yr. You can move to another location, where the average labor rate is 60¢/hr., but defective part costs, due to lack of skill and increased inspection, will cost $50,000 and it will cost $1,000,000 to move and re-equip satisfactorily. What factors enter into the decision ($300,000 saved on labor), and on what assumptions would you advise moving? Do you consider it ethical to move an industry from a community?

B. Design Economics.

1. What arguments pro and con arise in considering whether small parts of machines shall be made from die castings or pressed steel or brass?
2. Name various points influencing the change in large machine parts from castings to structural steel?
3. What are the advantages and disadvantages in carrying stocks of completed machines?
4. What initiates the development of new products?
5. Assuming a market price for rotating machines based on standard capacity and speed, how is it possible to justify and recover the expense of making special modifications for individual customers?

C. Materials.

1. What factors should be investigated in adopting a new material of improved properties at same price, in place of an old one, *e.g.* bronze of higher strength and ductility?
2. How would you determine whether to pioneer (and possibly control the patent situation) or follow competitors (paying license if necessary) in development of a new major material or process, such as tungsten carbide for tools, beryllium copper springs or alzak treatment for reflectors.

NECROLOGY

FRANK LEWIS EIDMANN

Frank Lewis Eidmann, Vice President of the Society 1941–42, was born December 20, 1887, at Kingston, N. Y., died suddenly September 4, 1941.

Vice President Eidmann graduated from the Stevens Prep. School in 1905, and from Stevens Institute of Technology in 1909, with the degree of M. E. He taught mechanical engineering laboratory at Stevens the first year; 1909–13, he worked in the shops of the Olds Gas Power Co., Lansing, Mich.; 1913–15, instructor in mechanical engineering, Rensselaer Polytechnic Institute; 1915–16, engineer of development and production equipment with American-LaFrance Fire Engine Co., Elmira, N. Y.; 1916–17, plant engineer with Heald Machine Co., Worcester, Mass., organized industrial relations departments and retained general supervision of same; 1917–18, production superintendent and mechanical engineer of Cowan Truck Co., Holyoke, Mass.; 1918–19, supervising instructor of air station engineer officers' division, U. S. Navy Gas Engine School with rank of Lieutenant (j.g.) U. S. N. R. F.; the next year going back to the Cowan Truck Co. In 1921–23, he was consulting engineer for the Barrett-Cravens Co., Chicago, developing a new type of hand lift truck and a new line of portable elevators for this company. Consulting engineer for the Revolvator Co., Jersey City, developing a new hand lift truck and a number of improvements on existing line of elevators for this company. From 1923 to 1930, he was Associate Professor at Princeton in charge of courses in machine design, gas engine design, principles of business, principles of industrial management and manufacturing methods. The spring term of 1930 he was exchange professor at Columbia University and in 1931 became Professor of Mechanical Engineering at Columbia in machine design courses.

Vice President Eidmann had been an active member of the Society since 1925; a member of the Council 1931–34; and a member of many committees. He will be remembered for his "Clearing House for Machine Design." He was also a member of the American Society of Mechanical Engineers, Society of Automotive Engineers and the Association of Lift Truck & Portable Elevator Manufacturers.

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AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS ELECT OFFICERS

David C. Prince, Manager, Commercial Engineering Department, General Electric Company, Schenectady, N. Y., was elected President. The other officers elected were: Vice-Presidents, N. S. Hibshman, Bethlehem, Pa.; J. Elmer Houseley, Alcoa, Tenn.; Arthur L. Jones, Denver, Colo.; Walter C. Smith, San Francisco, Calif.; C. A. Price, Hamilton, Ont.—Directors, Lester R. Gamble, Spokane, Wash.; T. G. LeClair, Chicago, Ill.; Fred R. Maxwell, Jr., Pensacola, Fla.—National Treasurer, W. I. Slichter, New York, N. Y. (Re-elected).

THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS ELECT OFFICERS

James W. Parker, Vice-President, Charge of Engrg., Detroit Edison Company, President.

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SECTIONS AND BRANCHES

The Proceedings of the Sixth Annual Meeting of the **Allegheny Section** of the Society for the Promotion of Engineering Education are off the press and are available at fifty cents a copy. The following addresses are included: "Fundamentals of Professional Education," by Elliott D. Smith, Chairman of the Department of Economics, Yale University; "The Scientific-Technological Stem of Engineering Education," by William E. Wickenden, President, Case School of Applied Science; "The Humanistic-Social Stem of Engineering Education," by Willard E. Hotchkiss, Maurice Falk Professor of Social Relations, Carnegie Institute of Technology; "Man Still Reaches for the Stars," by Charles F. Lewis, Director, The Buhl Foundation; "Coördination of Industry with Engineering Colleges," by Walther Mathesius, Vice President, United States Steel Corporation of Delaware; "Coördination of Liberal Arts and Engineering Education—3–2 Plan," by William P. Tolley, President, Allegheny College; "Coöperative Engineering Education," by Douglas F. Miner, George Westinghouse Professor of Engineering, Carnegie Institute of Technology. Copies may be secured from Professor J. B. Rosenbach, Carnegie Institute of Technology, Pittsburgh, Pa.

Southwest.—Conforming to a recent request from engineering schools in Texas, New Mexico, and Oklahoma, Council approved the formation of a section of the Society for the Promotion of Engineering Education to be known as the Southwest Section. This section will include the states of Texas, New Mexico, and Oklahoma. This action, in effect, abandons the Texas Section and the Arkansas-Oklahoma Section.

Worcester Polytechnic Institute.—On June 9, 1941, a group of members of the Society for the Promotion of Engineering Education, who are members of the teaching staff of the Worcester Polytechnic Institute, effected a temporary organization preparatory to the establishment of a branch of the Society for the Promotion of Engineering Education. (Approved by Council at Ann Arbor Meeting.)

The following constitution was adopted.

The Worcester Polytechnic Institute Branch of the Society for the Promotion of Engineering Education shall consist of the members of that Society on the Staff of the Institute. Its officers shall

be a President, a Secretary, and an Executive Committee consisting of those officers and one other member. Officers shall be elected in June and will hold office for one year or until their successors are elected. If a vacancy occurs in one of the two offices, the Executive Committee will continue the discharge of its appropriate duties. The Executive Committee will arrange at least four meetings during the college year and will plan programs therefor.

The following officers were elected:

President: E. D. Wilson.
Secretary: F. J. Adams.
Member of Executive Committee: V. Siegfried.

FRANCIS J. ADAMS,
Secretary.

50TH ANNUAL MEETING, S. P. E. E.

The 50th annual meeting of the Society will be held in New York City, June 29–July 2, 1942.

BOOK REVIEWS

Radio-Frequency Measurements by Bridge and Resonance Methods. L. HARTSHORN. John Wiley and Sons, Inc. 265 pages. Price $4.50.

This book consists of 12 chapters starting with fundamental relations of R, C, and L. The chapter headings are generally self explanatory and are as follows: Impedance and Related Quantities; General Principles of Impedance Measurement: Resonance Methods; The General Principles of Screening and the Radio-Frequency Bridge; Generators; Detectors; Standards of Capacitance; Resistors; Standard Inductors; Measurement of Capacitance and Inductance by Resonance Methods; Resistance, Power Factor, Decrement, Etc., by Resonance Methods; Bridge Methods; Methods for Very Short Waves.

In chapter 3 the author has given a very fine discussion of screening of the various components of Radio-Frequency Bridges. In chapter 4 there are circuits and constants for many types of vacuum tube oscillators. Chapter 5 discusses the use of several types of detectors along with various vacuum tube detector circuits.

There are no illustrative problems in this book.

This book should find a use in a radio frequency experimental laboratory and as a reference book.

P. E. RUSH

Introduction to Electrical Engineering. GEORGE V. MUELLER. McGraw-Hill Book Company, Inc. First Editions, 306 pages Price $2.75.

In this text the author has taken up the underlying principles of the electric, magnetic and dielectric circuits when excited by D.C. Applications of these circuits are taken up throughout the text.

There are ten chapters under the following headings. The number of problems at the end of each chapter is also given.

Chapter	Title	Problems
I.	Some Fundamental Ideas about Electricity.	(8)
II.	Applications of Ohm's Law and Kirchhoff's Laws.	(40)
III.	Further Applications of Ohm's Law and Kirchhoff's Laws.	(24)
IV.	Properties of Metallic Conductors and of Insulators.	(24)
V.	Nonlinear Resistance Circuits.	(19)
VI.	Electrochemistry.	(17)
VII.	Magnetic Circuits and Fields.	(44)
VIII.	Induced and Generated Electromotive Force.	(42)
IX.	The Dielectric Circuit.	(35)
X.	Electronic Tubes and Circuits.	(22)

The author has included a large number of example problems throughout the text which are worked out in detail.

This book is very thorough and should find a place as text for a first course to electrical engineering juniors.

P. E. RUSH

Experimental Electrical Engineering. KARAPETOFF. Revised by B. C. Dennison. Vol. II, 4th Edition, 814 pages. John Wiley and Sons. Price $7.50.

This new fourth edition of Vol. II has been completely revised and reset. Many more drawings and cuts have been included which help to clarify illustrations. The 814 pages include 35 chapters of textbook material pertaining to the general subject of electrical engineering circuits and equipment. Throughout these chapters some 163 laboratory experiments are carefully outlined for student use. The clear cut presentation of the theories involved together with quite a complete list of up-to-date references makes it possible for students to obtain complete information concerning each subject treated.

Some new methods and types of apparatus are described such as the Allen and Gross fault locater for overhead line losses, and the Crocker-Wheeler adjustable speed A.C. motor.

Electrical engineering junior and senior students, especially where time permits, should find this revised edition a very real help in their study of electrical engineering subjects.

R. C. GORHAM

Electric and Magnetic Fields. STEPHEN S. ATTWOOD. Second Edition, 430 pages, New York: John Wiley & Sons, Inc. $4.50.

Like the first edition this one is divided into four parts:

I. The Electric Field—8 chapters.
II. The Magnetic Field—4 chapters.
III. The Ferromagnetic Field—3 chapters.
IV. Combined Electric and Magnetic Fields—2 chapters.

Appendix I, 7 pages, is a treatment of "Electrons in Atoms"; Appendix II, 7 pages, is a "Historical Outline." There are sixteen tables listed throughout the book.

This edition has in it a large number of drawings and sketches of both electric and magnetic fields of various geometrical forms. Prominent methods of "field mapping" are used appropriately.

There are several symbolical solutions of problems, and a generous supply of problems for student drill is included at the end of chapters.

While revising certain material which appeared in the first edition some new information of a basic nature has been added including elements of the electronic structure of the atom, certain phases of kinetic gas theory, and molecular data for gases, liquids, and solids. Chapter VI, "Space Charge. Laplace and Poisson Equations," is an addition. Magnetization curves cover a wider range of materials; skin effect and iron losses due to hysteresis and eddy currents have been given more attention; dielectric theory now includes absorption properties of a condenser and the dependence of the dielectric "constant" on frequency; and the field of a moving charge and radiation from a dipole oscillator are included in Part IV. Some new problems have been added to the new second edition, while others have been revised.

This book should provide a splendid guide as a text for electrical engineering students in their study of "Electric and Magnetic Fields."

R. C. GORHAM

Mathematical Tables. HERBERT B. DWIGHT. N. Y., McGraw-Hill Book Company, Inc, 1941. Price $2.50.

This book differs from the ordinary sets of mathematical tables in several respects. In the first place, the natural functions and their logarithms are given for hundredths of degrees. There are tables of the sines and cosines of thousandths of radians. In addition to these, there are tables of some higher mathematical functions such as: Gregory-Newton Interpolation Coefficients, Surface Zonal Harmonics, and the Riemann Zeto Function.

In the opinion of the reviewer the type is so small that the usefulness of the book is limited.

JOHN C. KNIPP

Elementary Calculus. VOLNEY H. WELLS. N. Y., D. Van Nostrand, Inc., 1941. Price $3.25.

The reviewer believes that this book is an excellent one for an introductory course both in academic colleges and in engineering schools. Unlike most of the text-books of the elementary calculus, the processes of both differential and integral calculus are introduced very early in connection with polynomials and the fundamental principles are studied further as new functions (algebraic, trigonometric, exponential and logarithmic) are considered.

Polar coördinates and their applications are presented in a separate chapter; but this chapter is so written that the instructor is afforded the opportunity of making the various sections parts of the earlier chapters, if he so desires.

The chapter on solid analytic geometry, although brief, is very fine for reference or study in connection with the work on partial differentiation and multiple integration. The appendix contains a complete list of the fundamentals of plane trigonometry and of plane analytic geometry. The table of eighty-three integrals is a valuable part of the book.

Another outstanding feature of this book is the numerous lists of well-graded exercises. The writer has divided these exercises into three groups A, B, and C. Those in group A are much like the ones worked in the illustrative examples. The exercises in group B are more difficult. The problems in group C, in general, require much more thought than those of groups A and B. Thus, maximum of flexibility in determining the length of the course is permitted the instructor.

J. C. KNIPP

An Engineers' Manual of Statistical Methods. LESLIE E. SIMON. New York, John Wiley & Sons, 1941, pp. ix, 231, charts. $2.75.

A medical doctor who had become well-read in economics once said that it had taken him a long time to realize that neither medicine nor economics was as complicated as the language used by their practitioners. After a study of Major Simon's book, we may conclude that statistics also need not be mysterious. The purpose of the author is indicated on the jacket of the book by eight brass tacks; unquestionably he has achieved his purpose of making one branch of statistical method available for definite practical application.

In recent years those larger companies which could afford it have developed the use of statistical methods for the purpose of controlling quality of manufacture. This book makes adequate techniques available to any concern which has a competent engineer on its staff; it should forestall attempts to operate on a layman's conception of sampling. It may be said at the outset that the author writes in a pleasing manner; he is understandable. He wastes no time in getting started. In his first dozen pages he distinguishes between sampling by attributes and sampling by variables, demonstrates that a small sample of a certain quality is likely to come from a lot somewhat below this level of quality, and then proposes that "statistical methods enable one to write specifications which offer reliable assurance of the quality of products accepted thereunder, which are fair to producer and consumer, and which minimize chance rejections of good quality and chance acceptances of poor quality." He then shows the general plan by which this can

be done—the establishment of a satisfactory level of quality and its maintenance by the check of the trend of frequent small samples.

Inspection of a lot by attributes is facilitated by reading directly from charts (based on the solution of the incomplete beta-function ratio). Since a small sample is likely to represent too wide a range of inaccuracy, proper procedure indicates more samples—say 200 to 600. To overcome the objections of the practical man to such numbers, a procedure called the grand-lot scheme is introduced. This is the grouping together of simultaneous or successive lots believed to be essentially the same; moderate samples from each will give the larger totals required. Lots which sample low are dubbed "suspected mavericks" and subjected to more intensive examination. The general method is applicable to the acceptance of purchased goods and to the control of their manufacture. Continuous sampling frequently gives a good indication of the nature of an assignable cause for departure from specified quality; it is then an engineering task to eliminate the difficulty.

Introducing the method of sampling by variables, the author first explains the significance of the average and the standard deviation, together with the practical difficulties of their use. Inspection of related lots by variables is accomplished by tabulating average and standard deviation for series of samples, with suspected mavericks and extreme suspected mavericks set at ± 2 and ± 3 standard deviations of the standard deviation respectively. The value of this method in process quality control is generally known; it reduces waste in production and labor in inspection. More than that, it makes possible the maintenance of variability of product within economic limits.

Much of the latter part of the book is devoted to the question of sample size and to other statistical techniques. To the engineer, the fourth appendix contains much of interest in its treatment of specifications and quality. The careful distinction between design specification and inspection specification, and their relationship to a quality standard, is valuable whether one is greatly interested in industrial statistics or not.

Those who are familiar with Shewhart's pioneer work in this field will recognize his influence. That in no way detracts from Major Simon's achievement in developing the statistical method for the particular use of the Ordnance Department and then writing it up in a form intelligible to engineers in general. As this review is written, a class of forty-odd people is meeting weekly under the Engineering Defense Training program in Pittsburgh, with this book as its text. Engineers will unquestionably find it advisable to add statistical methods to their collection of tools.

LAWRENCE R. GUILD

Design of Machine Elements, Revised Ed. V. M. FAIRES. The Macmillan Co. $4.00.

Problems on the Design of Machine Elements, Revised Ed. V. M. FAIRES AND R. M. WINGREN. The Macmillan Co. $1.40.

The practice of machine design is subject to continual change as research and improved practices increase the knowledge of the subject. Revision of this text has been made to bring up to date certain sections of the book.

A new chapter has been added on fatigue stresses and stress concentrations and the use of the dynamic loading method has been used throughout for the design of toothed gearing. Also included are information concerning the determination of stresses in welded connections, use of the hydrodynamic theory for the design of thick-film journal bearings and additional data on the properties of materials.

While the book is primarily intended as a text for junior and senior design courses, it is also very useful as a reference.

A companion volume, "Problems on the Design of Machine Elements," contains over 1000 problems illustrating applications covered in the text.

F. G. BECKWITH

Non-Ferrous Production Metallurgy. JOHN L. BRAY, Head, School of Chemical and Metallurgical Engineering, Purdue University. John Wiley & Sons, Inc., New York, 1941. Pp. 430. $4.00.

Three general chapters, "Introduction," "Metals and Ores," and "Slags and Fluxes," cover some 25 pages. A fairly satisfactory introduction, but seems not to have been as carefully prepared as most of the book. Then follow twenty-three chapters, each dealing with an individual metal, the list: Aluminum, Antimony, Arsenic, Beryllium, Bismuth, Cadmium, Chromium, Cobalt, Copper, Gold, Lead, Magnesium, Manganese, Mercury, Molybdenum, Nickel, Platinum, Selenium and Tellurium, Silver, Tin, Tungsten, Vanadium, Zinc, 371 pages; and finally two chapters, "Secondary Metals" and "Marketing of Bullion, Ores and Concentrates"; and a good-sixteen page index, the last an important item.

This book was written primarily to provide a more satisfactory text than has recently been available for classroom instruction and study aid in teaching these subjects. In his preface, the author outlines briefly some of his ideas for such a book, of which the following appeal strongly to the present reviewer, namely that the illustrations should all be very simple line drawings, showing only principal parts and dimensions. No photographs are used, for sev-

eral good reasons. There should be careful and full explanations of every important process from a chemical standpoint, with comparatively little emphasis on operating details or special processes; and general statistical material be kept to a minimum.

Professor Bray has used a simple outline, very similar for all the metals, telling of its "History," "Economics and Statistics," "Properties of the Metal," "Marketing, Prices and Stocks," "Uses," "Alloys," "Ores," then the methods of producing the metal or its commercial compounds, and "Refining." Copper occupies 85 of the 371 pages on the individual metals, lead 48, zinc 45, gold 40, aluminum, silver and tin 14 each, with 4 to 9 for each of the other metals—Gold is still rated fairly important, in spite of its present rather peculiar situation—! ! Part of the copper section is taken up with a discussion of roasting in general. This major part of the book is very good. The material is brought well up to current practice, mostly in clear, well stated phraseology, and a large amount of pertinent metallurgical information is presented. In the early chapters there are a number of cases of indefinite wording, but for the most part these are not of such moment except perhaps as giving somewhat unfavorable early impression. There are a few such in later chapters, as the first sentence in paragraph 190 on page 138. This particular form has become so common perhaps it should not be criticized even though the words actually contradict the impression presumably intended.

For two reasons the present reviewer plans to use this book for a course in general metallurgy this fall, 1st, it appears to him to be the most satisfactory text now offered, and 2nd, the price, $4.00, is lower than that of most other possible books.

S. L. GOODALE

RESEARCH AS A FIELD FOR ENGINEERS

By ALFRED H. WHITE, President

War is old, but the implements of war are changing constantly and in these days almost daily. We are told that the design of a bombing plane is practically obsolete before a plant for its manufacture can be retooled and production started in quantity. A similar situation holds for the material for warfare on land and on water. The intensity of interest in the present world war and our own preparations for defense throw the spotlight on this panorama of change in implements for warfare. What is not apparent to the spectator in the theatre listening to the commentator and looking at the pictures flashed on the screen is the amount of systematic research which underlies each of the new models shown. According to the Greek mythology, Minerva, the goddess of wisdom, emerged fully grown from the head of Jupiter. Something of that myth still persists in the minds of most people who believe that an improved plane or tank takes shape in the inspired mind of some inventor and is brought to visual form much as a sculptor shapes a statue from a block of stone.

The ordinary citizen has only a faint conception of the hundreds of scientists, each working on his own particular task, whose valuable data are brought together in the successful new model. He would be equally astonished if he were told that most of our leading industrial corporations have for years been working with almost the present intensity to improve their products and processes for the production of materials for peace-time purposes. Indeed, if it had not been for the research organizations which had thus been built up, our present national defense effort would have had a far slower acceleration.

The National Resources Planning Board released a few months ago a study entitled *Research—A National Resource,* with Part II devoted to Industrial Research and I extract a few sentences from their summary of findings:

> "The United States has become the acknowledged leader in industrial research.
>
> "American industry employs over 70,000 research workers in over 2200 laboratories at an estimated annual cost of the order of $300,000,000.
>
> "Industry looks to the Universities for trained technical men, and for principal advances on the frontiers of science."

In the body of the report there is a table showing that 35,553 of the 70,033 research workers in the United States are professionally trained, and that of this number 14,980 are engineers, a group surpassed in size only by the chemists with 15,700. These two groups together comprise 83 per cent of the research personnel with professional training.

This same report contains a study of the rate of growth of industrial research from 1920 to 1940 which indicates that in 1920 the research personnel numbered only about 8000 with a curve of growth ascending at the rate of about 10 per cent a year. The rate of growth was somewhat faster in the years 1927 to 1930 and also from 1938 to 1940 and showed a recession, surprisingly small, with the low point in 1933. Many of our most progressive corporations maintained their research staffs at full level during the depression and developed new products or introduced economies thereby which enabled them to open new markets and maintain employment at a higher level. The report on Industrial Research also includes this sentence in its summary of findings.

> "Industrial research acts as a protection against unfavorable changes taking place both within and without an industry."

It may be safely assumed that industrial research has not yet reached its maximum growth because a considerable proportion of our industries are only commencing to appreciate this important tool. If we may assume that the curve of 10 per cent cumulative increase will persist for the next ten years we may expect to see 39,000 engineers employed in research work in 1950.

The National Association of Manufacturers released a report only a few days ago stating that an unprecedented total of $117,490,000 would be spent for research this year by the manufacturing industries of this country. We have usually thought of the chemical industries as being leaders in research but they take only second place with an expenditure of $30,695,000 while first place goes to machinery, excluding transportation, with $45,474,000 and third place to transportation equipment with $10,259,000. In terms of relative expenditure to value of gross sales, the order is the same, the machinery industry spending 3.0 per cent of its gross sales for research, while the chemical industry spent 2.4 per cent, and the transportation equipment industry 2.0 per cent.

The figures compiled from the questionnaire sent out by our own Society a year ago and published in the JOURNAL of December 1940 showed that in the year 1939–40 the engineering colleges of the United States conferred 11,358 first degrees, 1329 masters and 108 doctors degrees. This total of 12,795 degrees is certainly

larger than the number of graduates who took industrial positions because the recipients of higher degrees came from the group receiving bachelor's degrees in previous years. We may assume as a rough approximation that 10,000 engineering graduates with bachelor's degrees and 1400 with higher degrees took industrial positions in 1940. If the research organizations expanded ten per cent in that year they would have employed 1500 engineers to take care of expansion, without considering replacements. The men with higher degrees are better fitted for research positions and the demands of the research units would have been approximately satisfied, at least arithmetically, if all of the recipients of higher degrees had become research workers.

If the research units maintain their present rate of growth for the next ten years the number of engineers employed in this work will be 39,000 in 1950 and the number of men to be added in 1951, not counting replacements, will be 3900. The research organization has come into prominence as an employer of engineering graduates only during the last twenty years. It now employs over ten per cent of our graduates and promises to be an increasingly important employer in the next decade. It is a field worthy of careful consideration by our better students.

MORE INTENSIVE DEFENSE TRAINING IN PRODUCTION SUPERVISION NEEDED

By R. A. SEATON *

Training for supervisory and managerial personnel has been an important part of the Engineering Defense Training and Engineering, Science, and Management Defense Training programs since their beginning, but much more of such training is currently needed. With thousands of additional defense workers being employed in our factories daily, the need for large numbers of trained and effective supervisors is obvious.

Colleges of engineering and of business administration are doing much to meet this imperative need through their defense training programs. Under the Engineering Defense Training program of last year, over 19,000 persons were enrolled in courses in Industrial Management, Production Engineering, and Production Supervision. In the Engineering, Science, and Management Defense Training program of this year, not only engineering colleges, but collegiate schools of business administration, are participating. Thus it is now possible to approve courses not normally given by the engineering colleges, such as Cost Accounting, Personnel Management, Statistics, Procurement and Stores, and Budgetary Control. Up to October 1, 1941, 90 such courses were approved to accommodate a maximum of 10,184 trainees, while during the same period courses for an additional 10,515 students were provided for in the various phases of Industrial Engineering. Thus the authorized enrollment in classes in the fields of production supervision and management for the first three months in the Engineering, Science, and Management Defense Training program slightly exceeded the total number of enrollees in the engineering phases of production supervision for the entire Engineering Defense Training program.

The kind of instruction given in the defense courses differs somewhat from that given in the usual college course. Defense instruction must be short, specific, and closely related to the job to be performed; time is too limited to give the broad, comprehensive instruction desired under normal circumstances. Trainees are, for the most part, already employed, for most industrial companies

* Dean of the Division of Engineering and Architecture, Kansas State College, absent on leave to serve as Director of Engineering, Science, and Management Defense Training in the United States Office of Education.

favor the policy of promotion from within. The classes, therefore, must be on a part-time basis for the benefit of men who are already working full time and are frequently called upon for considerable overtime work.

The Training within Industry staff of the Office of Production Management, coöperating with the Engineering, Science, and Management Defense Training staff, has issued a pamphlet that lists the minimum essentials of supervisory training most urgently needed in the defense program. These items are recommended for inclusion in all defense training courses for production supervisors. They can be given in short, intensive, practical courses that will give the students quickly the essential techniques and understanding most needed at the present time. Later, if time and opportunity permit, such instruction can be supplemented to whatever degree may seem necessary. The recommendations are as follows:

Organization.—Good organization is the backbone of the defense effort, and should be so emphasized. The following points are particularly important:

1. *Get a thorough understanding of "good organization."*
   Stress departmental rather than top company organization, for this is where most of the men's work experience lies.

2. *Give practice in charting the organization close to the men's experience.*
   Have them chart their own companies, plants, or departments or the school which they are attending. Have them "set up" several typical departments under different conditions. Acquaint them with the several methods of charting. Be sure they understand that charts are not "sacred" but that during this expansion period they may need to be changed weekly.

3. *Get an understanding and appreciation of how people function in an organization.*
   Point out that a chart is only an aid—a means to an end. See that principles of line and staff are understood. Use actual situations in local plants to illustrate. Stress the importance of coöperation and understanding—that these are more important than strict adherence to organizational theory.

4. *Give practice in the use of aids to develop understanding and coöperation.*
   Have each man describe in writing his own and several other positions, bringing out the three important features of every position:

Just what responsibility?
How much authority?
Relationships with others (line and staff).

Have each man "set up" an organization and explain to his "staff" their new jobs.

5. *Give them "perspective."*
See that they understand what to expect and how to better "fit in" their own work situations. Point out that perfect organization is never achieved—that prerogatives, personalities, and other factors will always cause friction and difficulty—that it is important to understand this, both as "supervisor" and "supervised."

Production.—Getting out production is the Number One problem today, so every practical help should be offered.

1. *Get an understanding of production planning, its importance and problems.*
Explain the steps in the over-all planning process necessary on selected defense orders, *i.e.*, determination of plant capacity, number and kinds of machines, materials, tools, employment, training—all by installation or procurement dates.
Stress plant and mill scheduling—use typical local problems where possible.

2. *Develop an understanding of "how to organize for production."*
Point out the different organization requirements in various situations—from those where it is appropriate for the foremen to "do everything" to those where inventory, scheduling, product routing, instructions for processing, inspecting, stock chasing, and related paper work should be done by staff groups, leaving foremen free for their two primary jobs—getting out production and training men.

3. *Give help in understanding the over-all production plan.*
Have members chart or sketch on the blackboard the flow of work through several shops with which they are familiar. Stress importance of close coördination and timing; give them an appreciation of the seriousness of "hold ups" and the necessity for coöperation.

4. *Lift out and develop the fundamentals of production engineering.*
Give a practical, working understanding of time study, standards setting, methods studies, and wage payment plans in such

form and detail as fit the needs of each group. Do not present material beyond the present needs and immediate opportunity of the men to use.

5. *Develop "resourcefulness."*
Point out that production seldom flows smoothly—that "getting production" is a constant series of problems, interruptions, and irregularities—that the ability to solve difficulties "on the spot" is of first importance. Give members practical production problems illustrating purely shop difficulties as well as those involving "hold ups" and other relations with line and staff departments. Have them give solutions quickly —discuss fully later.

Men.—Enabling men to give of their best efforts and loyalties is the heart of the defense program. Out of all the phases of "personnel" the following are of particular importance *now:*

1. *Secure an understanding of the essentials of personal leadership.*
Analyze and discuss qualities and practices of good supervisors. Point out the need to keep close to employees—to know concretely what is happening to each and to his relationships with others.
Stress the importance of listening intelligently to grievances—of dealing with them promptly according to the plant procedure. Caution against sudden or frequent changes in matters concerning employees which might upset customary relationships.
Stress the importance of "telling them why"—and in advance whenever possible.
Use actual examples of these and other personnel problems; have members demonstrate how they would handle.

2. *Develop each supervisor into a competent "job instructor."*
The following points should be stressed and adequate practice should be offered to enable supervisors to do a good instruction job in their own shops:
   (*a*) How to prepare a simple training plan.
   (*b*) How to analyze an operation for instruction purposes, picking out key points.
   (*c*) How to put over the instruction.
   (*d*) How to follow-up for effective results.

3. *Develop an understanding of "upgrading" and how it should be done on the job.*
Point out the importance of intelligent upgrading as the basis of shop efficiency and the practical working of democracy.

Develop, in typical departments and between departments, how each of the four phases of upgrading would operate:

Line of progression.

Rate adjustments corresponding to job performance and job movement.

Job rotation (when and where appropriate).

Supplementary instruction.

4. *Get an understanding of how to maintain safety on the job.* Stress that the "one right way to do a job" is the skilled—quality—safe way. Point out how accident data are usually presented and how they should be used—how accidents and near-accidents provide practical leads for preventive measures. Review safety rules of several plants—measures taken to enforce. Stress safe practice manuals—how best to use.

AIMS AND SCOPE OF THE MECHANICAL ENGINEERING CURRICULA *

By A. G. CHRISTIE

Professor of Mechanical Engineering, The Johns Hopkins University

Changing world conditions present new problems which require different applications of the laws of pure science. Under such circumstances, the mechanical engineering curriculum of every school should be under continuous critical study, for it must be adjusted to these changing conditions if instruction is to keep in step with technical progress. A prolonged depression followed by war abroad and emergency defense efforts at home have materially affected our national policies and our manufacturing practices. A review of the training of mechanical engineers throughout this period and an analysis of future requirements is not only opportune but highly necessary, to provide our youth with proper training under these new world-wide conditions.

Aims of a Mechanical Engineering Curriculum and Scope

The writer's views of what constitutes such a curriculum are unorthodox. An eminent engineer claims that there should be only one curriculum for all undergraduate engineering students which should embrace the fundamentals of the several branches of engineering. There is justification for this view, for my professional work, both here and abroad, has presented problems in the fields generally embraced in mechanical, electrical, civil, gas, mining and chemical engineering and these problems had to be solved. This has required more than a cursory knowledge of certain portions of these branches of engineering. My three years of college training were largely devoted to electrical studies, and my work has been principally mechanical since leaving college. As a consequence, my ideas of curricula are somewhat liberal.

What is Mechanical Engineering? A committee of the American Society of Mechanical Engineers has recently submitted the following definition:

Mechanical Engineering comprises the art and science of power generation, the transmission of power, and transportation by mechanical de-

* Presented at the Conference on Mechanical Engineering Instruction, Purdue University, June 29–July 3, 1941.

vices; of the production of machinery, tools and their utilization; and it includes research, design, development, application and the management functions of organization, operation maintenance and marketing.

This definition covers the various fields of activity of the Mechanical Engineer. Curricula must aim to prepare students for usefulness in these activities. Our discussions should determine how well this objective is attained.

The aims of a curriculum and of the teaching that puts it into effect should be the development of a well-trained undergraduate. He will not be a mechanical engineer upon graduation, for there will be much to learn of the art of engineering before he reaches competency. What is embraced in the term "well-trained"? Opinions differ. Some employers ask for graduates versed in the details of only a particular branch of the profession. The need of a knowledge of the fundamentals of other branches of engineering can be emphasized by the following illustrations.

In the field of power plant design, one needs to know something of structures to pass upon foundation designs; of fluid mechanics to appraise water channels or hydro installations and ducts or conduits for air or gas flows; of chemistry to determine feed water treatments; of materials to select suitable piping and other parts for high temperature steam; of electricity to choose auxiliary motors, control systems, communications and lighting; and of heat generation, transfer and transformation, as applied to boilers, turbines, extraction heaters, deaerators and condensers.

In manufacturing industries, the mechanical engineer should know materials, their physical and chemical properties, metallographic structure, weldability, and heat treatment; in design, one should evaluate the elastic properties of materials and their vibration characteristics; in shop administration, there is needed an understanding of machines, processes, material handling, labor policies, cost accounting and business methods.

As a useful citizen, the engineer should understand our political organization and governmental methods, the history of our institutions and the trend of social development. He should take his share of the responsibility in securing good government and in controlling the application of his technical developments. He should be able to express his views to his fellow citizens in simple, forcible English.

One's first conclusion is that these requirements call for highly specialized training in each case. On second thought, however, it will be seen that a graduate "well-trained" in English, the principle of mathematics, physics, chemistry, mechanics and materials and in the fundamentals of thermodynamics, electricity,

structures, political economy and industrial organization would readily comprehend the various problems that would present themselves and would know how to go about their solution. Thorough instruction in such courses should be the aim of a mechanical engineering curriculum. Its scope may be broadened in the final year by certain application courses to train the student in the use of these fundamentals.

Changes in Industry since 1929

During this period, the country has experienced one of the worst depressions in its history, with much unemployment. Within the past two years war abroad and our preparedness program has required maximum output from many industries and the organization of many new ones. We have passed from the period where college graduates could not get jobs commensurate with their training and ability, to the period where there is a dearth of college graduates and where emergency defense training courses have been started to give men with no college training some knowledge of a single specialty so that they may relieve in a small measure the present shortage of trained engineers. Obviously both conditions are abnormal but may be repeated in future years.

At the start of the depression, certain industrial executives asked for sales engineers only. This was clearly a mistake, for one cannot sell when no demand exists. Other industries placed emphasis upon economies in production and distribution which have had fruitful results in reducing costs and simplifying equipment and processes. In many cases, extended mechanization reduced expenses but increased unemployment. Finally, the rise in strength of the labor unions and certain of the New Deal laws have increased the importance of labor policies and personnel relationships. These factors tend to increase the importance of a knowledge of organization, control, and labor relations in industry.

In the search for new products to sell, industry sought inventions and organized research departments to aid in the search for new lines. Research laboratories were successful only when manned by highly trained, capable men. Hence the demand arose for men with postgraduate training.

Since 1929 new industries have developed and certain of the older industries have directed their efforts into different lines. For instance, many concerns now manufacture airplane engines, controls, and other parts. The production of aluminum and magnesium has become "big business." New alloys of many classes are now standard products. Former builders of refrigerating machines now furnish air conditioning equipment. Other examples

of change will come to mind, such as the plastics industry, new chemical products, sub-assembly production, etc.

These developments further emphasize the need of thorough training in broad fundamentals to enable the engineer to enter new fields and also of a reconsideration of emphasis and time to be spent on certain portions of fundamental courses. As an extreme example, the teaching and calculation of Hirn's analysis of the steam engine in a course in thermodynamics has little utility in modern industry that uses steam turbines.

Changes in Engineering Education since 1929

In the main, college attendance during this period increased partly because no employment was to be had on leaving high school and partly through subsidies under the National Youth Administration.

The depression period, with its lack of opportunity and the paternalistic attitude of the Government, did much to destroy the rugged individualism of many students. The idea that they would be cared for by Government jobs or otherwise led to the loss of initiative. It will take time to restore the old pioneer spirit of self reliance, invention and initiative among undergraduates.

Additions to teaching staffs over this period have been of excellent calibre, due to the availability of highly trained men. This led to better instruction of undergraduates and to the further encouragement and development of research in the engineering schools. Unfortunately, this condition does not exist at the moment. Such men are no longer available, due to the great demand for highly trained men and to the high salaries that are being paid by industry. Only less able men will be available for junior positions in teaching staffs unless the colleges can raise wages to levels comparable with industry.

The extension of graduate instruction in the various schools has presented difficulties. Many of the older men on the staffs of these schools have never had advanced training and such courses as they offer must suffer certain limitations. These men usually have heavy teaching schedules and frequently do consulting work on the side. They cannot be expected to undertake advanced studies in mathematics, physics and chemistry in their meagre spare time. It would therefore appear best to turn much of the post-graduate training over to the younger and more highly trained men.

Courses given by men who have become specialists in a particular field tend to become descriptive of detail and the basic fundamentals are often overlooked or insufficiently developed.

Great credit is due to E. C. P. D. for the general elevation of the standards of engineering education. These accomplishments are well known and need not be discussed further in this paper. Dugald C. Jackson's masterful report on "Present Status and Trends of Engineering Education in the United States" has led to constructive improvements in many schools. These several influences have led to changes in our curricula. Certain courses have been expanded. Others, such as drawing, and in some cases shop work, have yielded time that is now devoted to cultural subjects.

Probably the principal gain has been the emphasis placed upon fundamental subjects. Descriptive treatments have given place to mathematical analyses. The new chemistry makes greater demands upon reasoning powers than the older presentation when the properties of the elements had to be memorized. In the same way pure thermodynamics is replacing descriptive courses on boilers and engines. Machine design includes less of empiricism and the rule-of-thumb proportioning of parts and more of the analysis of stresses. In materials, discussion of physical properties has been replaced by detailed studies of the alloy theory, the equilibrium diagrams and metallographic methods of analysis as applied to iron and other metals.

Trend in Curriculum Development

While there is no standard curriculum of mechanical engineering in this country, there is a certain likeness in the curricula of our several colleges. Differences arise in the content of the several courses offered under the same or similar names and in the emphasis placed on certain portions of each subject. Other sessions at this conference will discuss more fully than is possible at this time the details of the several courses and the manner of their most effective presentation. The writer will endeavor to suggest certain trends in the development of the curriculum that should lead to a "well-trained" graduate.

In the first place, it has been recognized that some of the older curricula contained so many subjects per year that the student was overloaded. The only way each course could be completed in the prescribed time was by hurriedly studying the high points of that subject. This led to a superficial knowledge of each subject as the student relied largely upon memory. The work of every year should be planned to allow the student sufficient time to absorb and digest the substance of each course in a thorough manner and to learn to apply its principles to the solution of engineering problems.

The principles of the basic courses of mathematics, physics, chemistry and mechanics should be taught with the greatest thoroughness. This teaching can be more effective if the student is shown the application of each of these sciences to engineering problems, which presentation arouses his interest in the subject. The engineer should consider mathematics through differential equations as one of his tools and be as competent in its application as a mechanic with hammer and chisel. More and better chemistry is needed, for much of the engineer's later work will require the application of this chemistry. A grasp of classical physics which includes the properties of matter, theoretical mechanics, the laws of gases, heat, electricity, magnetism, optics, and sound is preferable to discussion of modern physics which concerns itself with the constitution of the atom, relativity, etc. The engineer needs to know these principles to understand radiant heat transfer, sound intensity, wave motion, spectroscopic analysis of substances, optical measurements on surfaces and supersonic phenomena. Mechanics forms the basis for the analysis of forces in machines and structures. It should include not only the tensile, compressive and torsional statically applied forces but also the dynamic forces that may be present, the resultant strain on the loaded parts, their natural periods of resonance and graphic methods for the solution of problems.

These basic courses are generally offered in the first two years, together with English, drawing, descriptive geometry, surveying, mechanism and in many cases shop work. An elaborate discussion of the contents of such courses is waived at this time.

The curriculum of the third and fourth years differs greatly among the colleges. This is the portion upon which there can be placed much thought for the optimum development of the "well-trained" man. The fundamental courses have already been stated. These courses, given in the last two years, should emphasize in the class room the theoretical treatment and should continually show the application of the mathematical, physical or chemical principles learned in the first two years. Descriptions of machines and processes should be at a minimum, leaving to the laboratory and to visits to plants the functions of familiarizing the student with current types and their operation.

Controversies have arisen over the displacement of hydraulics by fluid mechanics. From the point of view of the mechanical engineer, fluid mechanics is preferable. Hydraulics deals merely with one fluid, viz., cold water. But the mechanical engineer may have to deal with many other fluids, such as highly heated water, steam, mercury and diphenyl oxide vapors, hot and cold air, flue gases, natural and other fuel gases, and fuel and lubricating oils. The

application of aerodynamic methods of analysis to the flow of certain of these fluids in, through and around engineering structures requires a basic knowledge of the laws governing such phenomena. A study of fluid mechanics provides this comprehensive knowledge and therefore should have a prominent place in the curriculum.

Many schools have found a course in English offered in the last year is helpful. Students at that stage realize the need of training in clear exposition, both oral and in writing, and hence take a greater interest in and get more out of an English course of this character than at any other stage in their college careers.

Many curricula include courses of a specialized character, such as steam turbines, internal combustion engines, refrigeration, heating and ventilation, air conditioning, etc. These can all be classed as "application courses" since in general they merely apply the principles of the fundamental courses. Elementary or descriptive courses on these subjects should be debarred. Such application courses should be of limited number in any curriculum and should never be offered if time is taken from the basic engineering courses.

One will object that this program favors a curriculum of engineering fundamentals only and that little specialized training in mechanical engineering is contemplated. After all, isn't this a desideratum in a well planned four year course? Few students in college have a definite idea of their field work immediately after graduation, let alone ten years afterwards. In view of the rapid developments in the past and even more extensive ones in the future, a thorough knowledge of fundamentals is essential. With the latter, an engineer can readily comprehend the changes in practice and can soon acquaint himself with the details of a new development. In other words, the specialized student is narrowly limited and has difficulty in adjusting himself to changes. Our "well-trained" graduate is versatile and is prepared to carry his share of the work in this changing world.

Such curricula as indicated above are those provided for undergraduate instruction. Graduate instruction provides an opportunity for specialization. However, even graduate training should not be too narrow. Industry has discovered that the Doctor of Engineering with a thorough grasp of the more advanced mathematics, physics and chemistry makes in general a more competent advisor than one who has specialized for instance in air conditioning only. It is not intended to discuss the most desirable program of such advanced training in this paper.

The graduate of a four-year course often finds upon entering industry that he needs instruction in certain specialized courses that he did not take in college. The problem of such men was discussed

by the writer in his presidential address before A. S. M. E. entitled "Postgraduate Training of Young Mechanical Engineers" and reprinted in *Mechanical Engineering,* January 1940.

In closing, let me repeat again that the curriculum of mechanical engineering should emphasize the principles of mathematics, physics, chemistry and mechanics, that emphasis should be placed upon fundamentals rather than practice in thermodynamics, electricity, structural design, fluid flow and materials, and that English, political economy, industrial organization be emphasized. Other courses, even the mechanic arts, should receive lesser emphasis. The completion of such a curriculum should lead to a "well-trained" engineer.

THE PRESENT STATUS OF "NON-TECHNICAL" ENGINEERING EDUCATION IN AMERICAN UNIVERSITIES

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Educators in departments of engineering do not need to be reminded of the significance attached to "non-technical" course work in recent years. Since "engineering bridges the gulf between the impersonal exact sciences and the more human and personal affairs of economics and sociology,"* students clearly require more than a passing acquaintance with humanistic fields of study. The problem, however, is to determine the *optimum* extent of this acquaintance. One step toward a solution involves an examination of the present status of "non-technical" courses in engineering curricula. This paper presents a brief analysis of 1939–40 curricula by the sampling method in an attempt to disclose the present position of such courses in the curriculum.

The basic data for this survey of "non-technical" course requirements were obtained from an examination of the catalogs of 40 institutions, which represents a sample of about 25 per cent of the colleges that offer work in engineering. These schools may be classified conveniently into five groups (with the exception of curricula for Architecture, many of which involve 5-year plans), as shown in Table I. These 40 institutions are of all size groups. Some have engineering enrollments of less than 500 students, while for others the number exceeds 2,500. The distribution of enrollments in the institutions studied, according to data published in the JOURNAL OF ENGINEERING EDUCATION for January, 1940, is shown in Table II.

Data were collected, whenever possible, on the curricular requirements of 10 departments of instruction. Enrollments by departments of instruction for land grant colleges were published in the United States Office of Education *Bulletin* No. 2 for 1935. Since 16 of the 40 institutions here examined were included in that report, approximate departmental weights were derived on the basis of the departmental enrollment figures for these 16 schools. The weights appear in the list of departments in Table III, and permit

* Dugald C. Jackson, "Present Status and Trends of Engineering Education in the United States," p. 12.

TABLE I

CLASSIFICATION OF INSTITUTIONS STUDIED*

5-YEAR PLANS: 2

*Columbia U.	Coll. City of New York

5-YEAR COÖPERATIVE PLANS: 6

Akron	Detroit	Marquette
Cincinnati	Drexel	Northeastern

BUSINESS-OPTION PLANS: 2

*Case	*Cornell U.

4-YEAR SEMESTER PLANS: 26

Alabama Poly.	Georgia Tech.	Purdue
Armour Tech.	U. of Ill.	Rensselaer
Cal. Tech.	Lehigh	Texas A & M
U. of Cal. (Berkeley)	M. I. T.	U. of Texas
Carnegie Tech.	U. of Mich.	Toledo
*Case	Okla. A & M	Wayne
*Columbia U.	Penn State	U. of Wisc.
Cooper Union	U. of Pa.	Worcester Poly.
*Cornell U.	U. of Pitt.	

4-YEAR QUARTER PLANS: 7

Iowa State	No. Car. State	V. P. I.
U. of Minn.	Ohio State	U. of Wash.
	Stanford	

* Three schools offer two curricula in each case; thus the total number of plans studied is 43, although only 40 schools are included.

TABLE II

ENROLLMENT DISTRIBUTION

Enrollment Group	Number of Schools*
0–499	7
500–999	7
1000–1499	14
1500–1999	6
2000–2499	4
2500 and up	3

* Separate enrollment data are not available for the Business Option plans at Case and at Cornell.

the computation of a single weighted figure to represent the collective standing of the various departments in a given institution. The comparison of institutions then may be accomplished by means of these weighted figures, as will be done in Table VI.

Examination of the curricular requirements of the 240 departments included in these 43 cases disclosed the fact that 16 "non-

TABLE III

DEPARTMENTS OF INSTRUCTION, AND ENROLLMENT WEIGHTS

Department	Enrollment Weight	Department	Enrollment Weight
Arch., or Arch. E.	2	Industrial E.	4
Ceramic E.	3	Mechanical E.	25
Chemical E.	13	Metallurgical E.	2
Civil E.	20	Mining E.	4
Electrical E.	27	Petroleum E.	2

technical" subjects were required of engineering students in one or more of the schools studied. The list of subjects is given in Table IV, together with the per cent of total "non-technical" time given to each subject. These courses may be grouped for greater con-

TABLE IV

"NON-TECHNICAL" SUBJECTS, AND PER CENT OF "NON-TECHNICAL" TIME PER SUBJECT

Accounting	3.9%	History	3.8%	Political Science	1.3%
Business Organization	4.5	Humanities	2.0	Psychology	0.1
Economics	19.2	Journalism	0.2	Social Science	1.3
English	39.6	Language	5.8	Sociology	0.9
General Electives	14.0	Law	1.9	Statistics	0.7
		Philosophy	0.8		

venience into five classes. The portion of "non-technical" time devoted to each of the classes appears in Table V, and may be taken as a norm of present curricular requirements.

Courses in some of these subjects conceivably may be regarded as "technical" rather than as "non-technical" in nature. For

TABLE V

"NON-TECHNICAL" COURSE GROUPS

Subject Group	"Non-technical" Time per Group
A. English	40%
B. Economics, Social Science, Sociology	21
C. General Electives	14
D. History, Humanities, Language, Philosophy, Political Science, Psychology	14
E. Accounting, Business Organization, Journalism, Law, Statistics	11

example, Accounting, English Report Writing, Journalism, Law, or Statistics are not as likely to be considered "cultural" by some persons as are History, Philosophy, or Political Science. Any attempt to segregate cultural courses is a dangerous one, however, since there is no sure method by which these courses may be dis-

tinguished. For this reason no attempt has been made in this study to deal with the cultural nature of courses. The attempt merely has been to include in the list all courses (except physical or biological sciences) required of engineering students but offered typically in Colleges of Arts or of Commerce.

A perplexing problem in course-classification involves the importance to be assigned to General Electives in a study of this sort. Many engineering curricula provide a number of hours of electives, but do not always specify whether these requirements may be satisfied by courses from within or from outside the student's college of enrollment. If catalog statements require that electives be "non-technical," full credit for these courses was allowed in this study. If lists of approved electives were given which would permit some plausible division of time between "technical" and "non-technical" courses, the indicated portion was included in total "non-technical" time; but if the list included only "technical" subjects, or if no list or statement was appended, no credit of this kind was given for electives.

Three other problems of course-classification may be noted. One problem arises because of the possibility of ready substitution of courses in the prescribed curriculum. Thus some schools may well have more "liberal" programs of instruction than is indicated by the data in Table VI, if "non-technical" courses may be substituted for "technical" ones. Since the only source of information for this study has been the data published in college catalogs, it has been necessary to disregard the possibility of substitution altogether.

A second problem is due to the fact that courses which appear to be "technical" in nature in so far as titles or departments of instruction are concerned may prove actually to be "non-technical" in content. No allowance can be made for this fact unless the investigator is to attempt the well-nigh impossible task of classifying each course at each institution in terms of the inadequate course descriptions usually published. The final problem arises because some of the institutions grant credit on the basis of quarter-hours while others use semester-hours. This problem need not concern us here since the data have been arranged as percentages of the total requirements for graduation and so are directly comparable.

The procedure involved in computing the percentages for Table VI may be explained briefly. The per cent of total time required for graduation that is devoted to "non-technical" courses was computed for each department by relating the total hours of required "non-technical" courses and electives to the total number of hours required for graduation. A single percentage figure then was ob-

tained for each college of engineering by computing a weighted average of the departmental percentages for that college, using as weights the quantities shown in Table III. The results thus obtained are presented in Table VI. The first column shows the weighted average percentages for each college, and the second gives the rank when arrayed from highest to lowest per cent. The remaining columns give the unweighted data by departments.

TABLE VII

DISTRIBUTION OF COLLEGE "NON-TECHNICAL" COURSE-TIME PERCENTAGES

Percentage Group	Number of Schools
0–4	1
5–9	3
10–14	12
15–19	18
20–24	5
25 and up	4

The distribution of the college percentage figures is significant. It is evident (Table VII) that a marked concentration exists about the median percentage (16.2 per cent) of Table VI. The median percentages by departments of instruction (Table VIII) also are of interest since they show on the average which departments have gone furthest in requiring "non-technical" courses for graduation. Industrial Engineering, as might be expected, devotes the largest

TABLE VIII

DEPARTMENTAL MEDIAN PERCENTAGES OF "NON-TECHNICAL" REQUIREMENTS

Department	Median	Department	Median
Arch., or Arch. E.	17%	Industrial E.	26%
Ceramic E.	15	Mechanical E.	16
Chemical E.	17	Metallurgical E.	15.5
Civil E.	16	Mining E.	9
Electrical E.	16	Petroleum E.	11

portion of graduation requirements to "non-technical" courses, while Mining and Petroleum Engineering fall well below the average requirements.

The comparison of per cent of "non-technical" course work with size of institution becomes a somewhat dangerous one in the case of the larger colleges, since the small number of such institutions affects the reliability of the averages on the basis of which the comparison is to be made. For this reason the last two enrollment groups of Table II have been combined in Table IX. The data

TABLE VI

Per Cent of Total Time Devoted to "Non-technical" Courses

Institution	College (43)		Arch. E. (17)		Ceramic E. (6)		Chem. E. (35)		Civil E. (42)		Elec. E. (41)		Indus. E. (17)		Mech. E. (43)		Metall. E. (18)		Mine E. (13)		Petro. E. (7)	
	Per cent	Rank	Per cent	Rank	Per cent	Rank	Per cent	Rank	Per cent	Rank	Per cent	Rank	Per cent	Rank	Per cent	Rank	Per cent	Rank	Per cent	Rank	Per cent	Rank
Akron	11.0	36	—	—	—	—	—	—	11	33*	11	33*	11	6	11	34*	—	—	—	—	—	—
Alabama Poly.	11.37	34	—	—	—	—	—	—	8	36*	11	33*	33	4*	11	34*	—	—	—	—	—	—
Armour Tech.	14.6	28	18	4*	—	—	17	12*	14	27*	19	13*	—	—	10	37*	—	—	—	—	—	—
Cal. Tech.	21.41	9	—	—	—	—	22	5*	21	7*	21	9*	—	—	22	7*	20	4*	—	—	—	—
U. of Cal.	0	43	0	17	—	—	—	—	—	—	0	41	—	—	0	43	0	18	0	13	0	7
Carnegie Tech.	21.51	8	—	—	—	—	22	5*	21	7*	21	9*	—	—	22	7*	24	1*	—	—	—	—
Case	15.93	25	—	—	—	—	16	19	16	19*	16	20*	—	—	16	20*	13	11	—	—	—	—
Case (Bus. Opt.)	25.95	3	—	—	—	—	26	2	26	2	27	2*	—	—	25	4	23	3	—	—	—	—
Cincinnati	11.71	32	—	—	—	—	9	29*	12	32	11	33*	22	10*	12	32*	—	—	—	—	—	—
C. C. N. Y. (5-Yr.)	27.0	1	—	—	—	—	27	1	27	1	27	2*	—	—	27	1	—	—	—	—	—	—
Columbia U.	18.28	14	—	—	—	—	17	12*	18	14*	19	13*	26	9	17	15*	17	7*	20	3	—	—
Columbia U. (5-Yr.)	26.08	2	—	—	—	—	24	3	25	3	26	4	32	6	24	5	24	1*	27	1	—	—
Cooper Union	7.15	41	—	—	—	—	8	31*	7	39*	7	38*	—	—	7	41*	—	—	—	—	—	—
Cornell U.	6.43	42	—	—	—	—	—	—	6	41	6	40	8	17	7	41*	—	—	—	—	—	—
Cornell (Bus. Opt.)	21.92	7	—	—	—	—	—	—	14	27*	24	5	—	—	26	2*	—	—	—	—	—	—
Detroit	22.98	5	22†	1	—	—	23	4	23	4*	23	6	—	—	23	6	—	—	—	—	—	—
Drexel	8.0	40	—	—	—	—	8	31*	8	36*	8	36*	—	—	8	40	—	—	—	—	—	—
Georgia Tech.	16.2	22*	21†	2	17	2	15	20*	14	27*	20	11*	—	—	14	29*	—	—	—	—	—	—
U. of Ill.	10.15	37	—	—	8	5*	14	22*	7	39*	7	38*	—	—	15	24*	8	14	7	9	—	—
Iowa State	13.36	30	10	16	10	4	9	29*	15	23*	14	28*	—	—	15	24*	—	—	9	7*	—	—
Lehigh	19.87	11	—	—	—	—	15	20*	21	7*	22	7*	33	4*	17	15*	17	7*	12	6	—	—
Marquette	18.66	12*	—	—	—	—	19	8*	18	14*	—	—	—	—	19	11*	—	—	—	—	—	—
M. I. T.	16.12	24	16†	6*	—	—	18	10*	15	23*	15	25*	36	2	15	24*	19	6	13	5	13	3
U. of Mich.	17.14	17	—	—	—	—	19	8*	19	12*	16	20*	—	—	16	20*	16	9	—	—	—	—
U. of Minn.	10.13	38	12†	12*	—	—	12	25	8	36*	13	31*	—	—	9	39*	7	15	5	11	6	5

M. I. T.	16.12	24	16†	6*	—	—	18	10*	15	23*	15	25*	36	2	15	24*	19	6	13	5	13	3		
U. of Mich.	17.14	17	—	—	—	—	19	8*	19	12*	16	20*	—	—	16	20*	16	9	—	—	—	—		
U. of Minn.	10.13	38	12†	12*	—	—	12	25	8	36*	13	31*	—	—	9	39*	7	15	5	11	6	5		

TABLE VI—*Continued*

Institution	College (43)		Arch. E. (17)		Ceramic E. (6)		Chem. E. (35)		Civil E. (42)		Elec. E. (41)		Indus. E. (17)		Mech. E. (43)		Metall. E. (18)		Mine E. (13)		Petro. E. (7)	
	Per cent	Rank	Per cent	Rank	Per cent	Rank	Per cent	Rank	Per cent	Rank	Per cent	Rank	Per cent	Rank	Per cent	Rank	Per cent	Rank	Per cent	Rank	Per cent	Rank
No. Car. State	15.2	27	13	9*	15	3	10	27*	16	19*	16	20*	19	12	16	20*	—	—	—	—	—	—
Northeastern	17.0	18	—	—	—	—	17	12*	17	17*	17	17*	16	14	17	15*	—	—	—	—	—	—
Ohio State‡	10.09‡	39‡	11†	14*	8	5*	6	34	5‡	42‡	14	28*	15	15	13	31	4	16*	6	10	5	6
Okla. A & M	11.97	31	16†	6*	—	—	11	26	10	34*	13	31*	22	10*	11	34*	—	—	—	—	—	—
Penn State	16.63	20	16	6*	—	—	—	—	17	17*	14	28*	18	13	19	11*	—	—	—	—	—	—
U. of Pa.	16.46	21	—	—	—	—	10	27*	13	30*	—	—	—	—	16	20*	—	—	—	—	—	—
U. of Pitt.	15.28	26	—	—	—	—	14	22*	16	19*	15	25*	30	8	15	24*	11	12	9	7*	11	4
Purdue	14.1	29	13	9*	—	—	13	24	13	30*	16	20*	—	—	14	29*	9	13	—	—	—	—
Rensselaer	16.2	22*	13	9*	—	—	17	12*	15	23*	15	25*	35	3	15	24*	20	4*	—	—	—	—
Stanford	25.82	4	—	—	—	—	—	—	23	4*	28	1	—	—	26	2*	—	—	24	2	—	—
Texas A & M	18.66	12*	18†	4*	—	—	17	12*	19	12*	19	13*	—	—	19	11*	—	—	—	—	18	1
U. of Texas	17.72	16	12†	12*	—	—	17	12*	21	7*	17	17*	—	—	17	15*	—	—	—	—	14	2
Toledo	18.0	15	—	—	—	—	—	—	18	14*	18	16	—	—	18	14	—	—	—	—	—	—
V. P. I.	16.95	19	11†	14*	18	1	17	12*	15	23*	17	17*	31	7	17	15*	15	10	15	4	—	—
U. of Wash.	11.26	35	20†	3	—	—	3	35	16	19*	8	36*	40	1	10	37*	—	—	—	—	—	—
Wayne	22.0	6	—	—	—	—	22	5*	22	6	22	7*	—	—	22	7*	—	—	—	—	—	—
U. of Wisc.	11.65	33	—	—	—	—	8	31*	10	34*	16	20*	—	—	12	32*	4	16*	4	12	—	—
Worcester Poly.	19.93	10	—	—	—	—	18	10*	21	7*	20	11*	—	—	20	10	—	—	—	—	—	—

* When two or more examples evidence the same per cent of time they carry the same rank; these ties are marked (*).

† Architectural curricula requiring 5 years work are marked (†) so they may be distinguished from ordinary 4-year courses.

‡ A new Civil Engineering curriculum soon will change the departmental figures to 9% and rank 36; and will change the college figures to 10.81% and rank 37.

TABLE IX

"NON-TECHNICAL" COURSE PERCENTAGES BY SIZE OF INSTITUTION

Enrollment Group	Median Time	Mean Time
0–499	18.0%	16.9%
500–999	18.7	17.5
1000–1499	15.2	15.3
1500–1999	16.2	14.9
2000 and up	14.1	12.1

apparently indicate that the smaller institutions tend to devote somewhat more of the undergraduate engineer's time to "non-technical" work than do the larger colleges.

The summary of "non-technical" course-time percentages relative to the 5-group classification of institutions presented in Table I above shows, as is to be expected, that 5-Year and Business Option courses devote a noticeably larger portion of the undergraduate's time to this field. The conclusion should be treated with caution, however, since the number of cases included is small.

TABLE X

"NON-TECHNICAL" COURSE PERCENTAGES BY TYPE OF COURSE

Type	Number of Schools	Per cent of Time
5-Year Courses	2	26.5
Business Option Courses	2	23.9
4-Year Semester Plans	26	15.3
Coöperative Plans	6	14.9
4-Year Quarter Plans	7	14.6

Judging on the basis of this sample, we may conclude that on the average engineering students in American universities devote 16 per cent of undergraduate time to "non-technical" subjects, of which 2/5 is given to English and 1/5 to Economics. The representative nature of such average requirements is open to question, however, because the deviations from the average are large. Thus the maximum assignment of time to "non-technical" work is 27 instead of 16 per cent, while the minimum is zero (although even in this case the requirement of proficiency examinations in English and History indicates that "non-technical" work is not entirely disregarded). Industrial Engineering students have "non-technical" requirements 50 per cent above the general average, while Mining and Petroleum Engineers fall well below the median of all students in this respect. In 5-year curricula "non-technical" course requirements show an expansion of some 50 per cent over the norm for 4-year plans; and small schools evidence some tendency

to emphasize cultural courses to a greater extent than do the larger institutions.

This summary indicates the present status of "non-technical" engineering education in American universities; and it permits the faculty of any one institution to relate its own curricular requirements to the average for all colleges. The study thus provides a point of departure for discussions of possible curricular modifications within the framework of 4-year courses, or of some of the implications of a change to a 5-year program. On the other hand, it makes no attempt to establish optimum requirements for "non-technical" work unless existing median requirements may be regarded in that light. These optimum requirements should be established by the members of the profession only after a searching examination of the objectives and methods of engineering education, which is beyond the scope of this paper.

REPORT OF THE COMMITTEE ON STUDENT SELECTION *

Heretofore the practice in pre-college guidance, admission and in college orientation has emphasized the scholarship qualifications needed for the successful pursuit of an engineering education. To an extent varying over a wide range, attention has been called in guidance to personal qualities and character as factors in industrial advancement.

The report of the Committee on Aims and Scope of Engineering Curricula sets up a dual purpose or a major and minor group of study objectives which require attention and careful consideration if the admirable purposes of the committee are to be more than ideals.

Guidance

To realize the "Aims" of the committee requires that guidance attempt a much more difficult task than it has generally assumed. The scientific-technological framework is partially understood by high school teachers and counselors. It can be explained and illustrated out of the knowledge and experience of engineering teachers and practising engineers who are the right hands of high school counseling.

Upon this mathematical-scientific base the structure has been built which the engineering college was expected to erect. The study of English, history, languages, economics, psychology and other required or optional subjects was given due importance largely as vehicles in expressing and consumating the scientific-technological objectives.

If proper weight is to be given the report of the Committee on Aims and Scope and if this Society proposes to pursue those purposes aggressively, then guidance and orientation must assume a larger and more difficult role.

To convey the meaning of the humanistic-sociological objectives to high school authorities and to engineering teachers demands an appreciation of the reasons for such emphasis. This by itself is not easy. But the next step is still more in advance of previous practice and requires a much more subtle ability to translate an ideal into understandable terms. Suppose we look at admission practices where certain difficulties to be met will appear and which have a bearing on guidance and orientation.

* Presented at the 49th Annual Meeting, S. P. E. E., University of Michigan, June 23–27, 1941.

Admission to Engineering Curricula

The usual criterion for admission is a diploma, supplemented by various degrees of scholarship which are required by a few engineering colleges. In still fewer instances, tests of knowledge in different fields or of aptitudes are required for information or for admission.

To attempt to probe the interest or understanding by the immature student of social purposes is difficult. At present reliable instruments are not available. The Present Status of Personality Trait Tests as presented by Dr. Robert Bernreuter * does not warrant reliance on such tests except their cautious use in research by those who are expert in assaying their reliability.

The personality inventory like an interest test may furnish material for discussion in guidance, in orientation, or in considering admission but only if the necessary mechanism is provided.

Present requirements for admission place the emphasis almost entirely on scholarship and when properly used this method of selection reduces the mortality materially.

If the interest in and understanding of elementary human and social purposes are to be considered in admission practice then the interview seems a necessary step in any attempt to evaluate the whole student.

There are two substantial reasons for urging consideration of personal contact of the applicant with a personnel officer or committee in those cases where doubt may arise concerning the social habits of the prospective student so far as they are reflected in his record or by his references.

First—There are no standard tests of validity which may be applied arbitrarily. There is doubt about such tests ever being more than suggestive. The interview seems to be the most promising present instrument by which to supplement high school grades, tests of knowledge, interests and aptitudes in any attempt to discover the social habits of the individual.

Second—There are apparent or real cases or desert areas in personal development, due to many reasons, in immature students. The important point is not merely to discover such dry spots but to weigh the possibility of watering and cultivating such areas of personality in order that they may give a normal yield or even an exceptional quality of human understanding.

The interview is at present the only or the most reliable measurement of ills and possible cures in this delicate and indefinite field of social understanding.

* *The Educational Record*, January, 1940, page 160.

In the process of setting up higher standards of achievement there will be parallel attempts to discover those best adapted to the humanistic-sociological aims of curricula and still retain due emphasis on ability to pursue the scientific foundation with equal or increased efficiency. The interviewer may be the counterbalance against vibration too far from present purposes. The process of education and of change in selection will be slow in its development into accord with the aims of the committee.

Orientation

To repeat, admission practice should attempt to discover *all* the assets and liabilities of the prospective student, balance the account, determine whether the school can offer adequate opportunities for the increase in those human assets which are the real wealth of the country.

If the school is just and honest in its admission of students with known defects, it should be prepared to offer corrective measures. While no one can be compelled to improve his habits or attitude, it is a failure on the part of the institution to ignore such defects. If the humanistic program is accepted as part and parcel of engineering education, then the liability for orientation programs of an individual character is definite and a subject for serious thought.

Society already assumes that engineering education is doing much of what is implied in the preceding discussion. Engineering colleges have been orienting students to face not only technical requirements but habit, personality and character patterns as well. Many teachers realize their moral and ethical responsibility to their students. This attitude should be inculcated in all teachers. The institutions should organize or program their efforts in order to accomplish more adequately what is being done personally and with little or no recognition of it or them by the institutions.

Present methods of selection fail to evaluate a few non-conformist individuals who are now rejected by arbitrary requirements for admission. Perhaps to pick them at that time requires some form of magic which we do not possess. The fact is that there are men who make great contributions to advancement and who could not meet the somewhat inflexible requirements to get in or to stay in an engineering college. This does not justify lowering the requirements for admission or admitting everyone even in an emergency, in the hope that the person of pronounced individuality, peculiarity or purpose may perchance be admitted and become a superman.

The competent interviewer is better able to weigh those who depart from the normal pattern of student than any arbitrary method of rejection. One genius who is understood, diagnosed, accepted

and then given a faculty adviser as a running mate may be the potential genius who has the strength often not only because his heart is right but because in addition he is allowed to have his head. Last October a plan was proposed by President Allan R. Cullimore of the Newark College of Engineering whereby a review of practices in selection and adjustment of engineering students could be made by an independent study of the subjects.

Professor Russell S. Bartlett, formerly of the faculty of Yale University and later of Phillips Exeter Academy, was attached to the faculty of the Newark College of Engineering. He was familiar with and participated in the test program at Yale University. He had also had experience in constructing and administering certain of the coöperative tests. His active interest in student personnel problems also recommended him.

The Society for the Promotion of Engineering Education and the Engineer's Council for Professional Development approved this further study in the field covered by the committee report presented at the 1940 convention of the Society for the Promotion of Engineering Education.

Professor Bartlett has visited engineering schools covering a wide geographical range and presents the results of his study in the following report. While the general subject was outlined to him he was not confined to any one phase of the subject but was asked to use his scientific training and his judgment as an educator familiar with the problems of selection and adjustment and to present his comments.

R. L. SACKETT, *Chairman*

RE-APPRAISAL OF VALUES IN THE SELECTION OF ENGINEERING STUDENTS

BY RUSSELL S. BARTLETT
Newark College of Engineering

Education for all, equal opportunity for each one, has long been accepted as fundamental in our way of life. Equal opportunity does not mean identical treatment. Rather, it means that each one shall have access to an education best fitted to his abilities and his needs, and that competent guidance shall be available to aid him in gaining that curriculum from which he can derive the greatest benefit. We must recognize that this ideal can never be achieved to perfection, since that would involve as many curricula as there are students. Still, we must accept the principle of individual differences and offer varied educational programs to take account of

those differences, since a curriculum suited to the abilities of one would be both useless and distasteful to another.

It is unfortunate if we, in the selection process, exclude a boy who is potentially a good engineer. It is a loss to society and it may be a calamity to the boy. We must be continually examining and refining our measuring instruments, to reduce the loss. To accompany any stiffening of the admissions requirements there should be further efforts to coöperate with high school guidance and personnel men, to aid the boy who has not yet found purpose and aim in his education. If the picture is not clear, in an individual case, it may be best to advise only, allowing the student to enter on a program contrary to that advice if he is determined. Where the chances of success are slight it is surely proper that we, better informed than the student, exercise the right of exclusion. If possible we should be constructive, positive rather than negative, telling him where to go rather than where he cannot go. Among constructive suggestions is that of another year in high school, to establish the right to admission, or to explore other possibilities.

Almost from the beginning education must have a dual purpose, preparation for further study or employment, and the exploration of possible fields in which the student may find his metier. School and college can coöperate in mapping the curriculum, each one recognizing the legitimate requirements and limitations of the other. We cannot expect the studies in high school to be planned with engineering school as the sole objective, certainly not before the last year or two. Just now our problem is to take the boy as we find him, at sixteen or seventeen or eighteen, with the training he has, with the personality and philosophy, with the inhibitions, the dislike of discipline, the lack of respect for authority, and give him what we can to help him to the fullest fruition, for the good of himself and of society.

Attempts to improve motivation or to adjust the curriculum to the student are not coddling; rather they are steps toward increased efficiency in teaching and learning. The intention is not to make the student's task easier but to enable him, through increased efficiency, to accomplish more difficult tasks. There is probably more discipline to be obtained from doing a hard job in the easiest, most efficient way than there is in doing a job intrinsically easy but unsuited to the training and abilities of the student. There will be a gain in motivation and a gain in disciplinary value when the program is adapted to the student; the gain in actual accomplishment may be many times as great.

An institution of higher education should admit only those students who have a reasonable chance of profiting by their studies.

Conversely it is the duty and responsibility of the institution to provide for each student admitted a program reasonably adapted to his needs and abilities. Where there is high selectivity, little flexibility may be required in the curriculum; with less rigid exclusion more diversity is needed after admission. Probably some flexibility and some selectivity are requisite to any solution; it is impossible to select so carefully that all may be treated alike after admission; no college can offer so varied a program as to offer a real opportunity to all applicants. There is as much need of provision for the superior as for the inferior student; possibly the need is even more pressing, since no college rejects a student because he is too good for it, or because the college is unable to offer the student a real challenge.

Methods of Selection

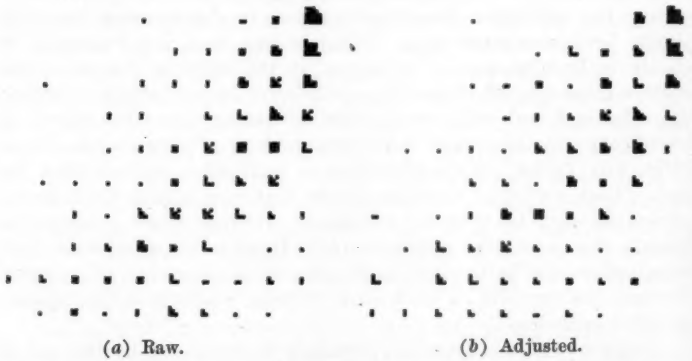
From the experience of engineering colleges, rank in class in high school is the most reliable index of later success, after assurance that the boy has taken enough science and mathematics to satisfy the admission requirements and to demonstrate that his ability lies along those lines. What he has done is a composite of ability and perseverence. Where there are sufficient numbers, the rank in class may be rendered more reliable by a program of rating the schools, based on a comparison of performance in college of boys from a certain school with their rank or achievement in school (Fig. 1). It may be possible thus to establish a critical rank for each school, such that a student below that rank has so little chance of success that he is better excluded. Despite many incalculable factors that preclude great accuracy, there is clear evidence that selection on the basis of rank in class in high school will greatly increase the survival of students in college, whether in engineering or other branches.

Accuracy of selection can certainly be improved by the use of tests to supplement high school records. In planning a testing program one should bear in mind the dual use of tests, as grounds for rejection or admission and as a basis for guidance after acceptance. Better selection can be obtained from a combination of test scores and high school performance than from either one alone. Figures from a non-selective college show that about one third of the entering freshmen became qualified sophomores the next year; at a selective college over ninety per cent regularly survive the first year, ten per cent representing the entire loss from whatever cause.

We must not expect too great accuracy from any combination of predictors that have been devised so far. Figure 2, an actual plot of high school performance against success in college, student by

student, is fairly typical of what we may expect to find. Wherever we may choose to draw a horizontal line, excluding those below, we find that some are rejected who would succeed, that there are some failures among those admitted. The higher the line the greater the number of successful students who are excluded, the fewer the failures among those admitted. There will always be the choice between these two evils.

Note that the high school record is least satisfactory as a predictor for border-line students. On the other hand, scores on the Psychological Examination of the American Council on Education, though relatively unreliable as predictors for good students, are most significant for students of inferior ability (see Fig. 3). It appears from this test and from others similarly weighted with the language factor that the importance of language facility to engineering has been considerably over-emphasized, though a student definitely weak in his command of English is at a real disadvantage. This test is evidently more useful as a selector than as a predictor



(*a*) Raw. (*b*) Adjusted.

FIG. 1.—A typical scatter diagram. Each small black square represents the record of one student. The square is placed in the appropriate cell to indicate the high school rank (horizontal) and the college average (vertical). 1(*a*) shows the rank as it would appear on the high school records, 1(*b*) the rank after it has been adjusted in each case to the quality or standing of the school. Such a scatter diagram is used in finding the correlation, or degree of relatedness of high school and college performance. When the two criteria agree well, the black squares lie mostly on a straight line pointing up and out, and the correlation is close to 1.00. Completely random scattering gives a correlation of 0.00. Where a good score on one axis generally accompanies a poor score on the other, negative correlations are found, down to — 1.00. For the scatter diagrams shown, college averages correlate 0.603 with raw high school rank and 0.712 with adjusted rank. Clearly the adjusted rank is better than the raw rank as an indicator of college success.

of success in engineering. Certainly it is useful in the very region where the high school record becomes unreliable. It may well be that each college can fix a critical score. One study showed that no student scoring in the lowest decile had a record in any degree creditable; more than half failed to reach the sophomore year.

Though tests like this one, of general aptitude, are not highly indicative for engineering, it is important that such a test be given, in high school if possible. Scores are indicative of general academic success. A student scoring well should be definitely encouraged to go to college. Test scores give a more cogent argument than the record of high school performance, or strengthen its verdict. The student who achieves a passable record in high school

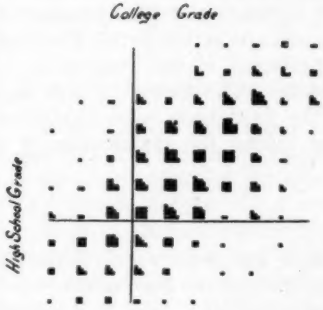


FIG. 2.

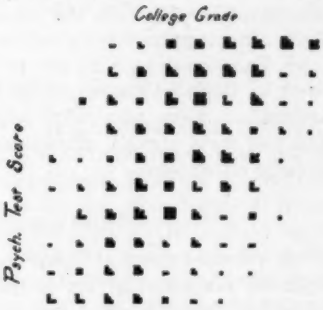


FIG. 3.

only through great effort is hardly college material, despite his fine earnestness and pertinacity. A poor showing on a test of general aptitude is reason for urging him to look elsewhere. A second or third measure of student power is valuable, if only to confirm the first, or to suggest further scrutiny where there is a conflict of evidence. Each institution must study its own entrance criteria in relation to student performance, not only in terms of correlations but also in the finer details of the scatter diagram, if most effective selection and guidance is to be practiced.

This Psychological Examination is the favored test of general aptitude, though there are others that have proved useful, including the Scholastic Aptitude Test of the College Entrance Examination Board and various state examinations.

Tests of general achievement in high school subjects, notably mathematics and science, are useful in selection and in guidance. The particular tests to be used and any critical score for admission depend upon local conditions. Where all applicants come with ex-

cellent training in mathematics, a superior performance is naturally looked for, and a test in that field may show little discrimination. A boy from a poor school should receive concessions, in that a poor score on a test may indicate superlative performance, considering the inferior training that the boy has had. A test in English, like the test of general aptitude, is most useful for guidance though it may yield a critical score of value.

There are at least three sets of achievement tests that give good results: the examinations of the College Entrance Examination Board, both April and June series; the tests of the Coöperative Test Service; and the Iowa Placement Examinations, both training and aptitude. It is hard to choose between them. In fact, one may serve better at one college, another at a college where different conditions obtain. On the whole it appears that the Coöperative Tests have kept up with changing conditions rather better than the Iowa Examinations, and are to be preferred where freedom is desired in the administration of the tests. The College Board Examinations serve admirably where the fixed time is no hindrance and the wide spread of centers for taking the examination is a definite advantage.

Guidance and Counselling

A recent report of your committee has dealt very completely with the matter of giving to the student and the high school counsellor information about engineering education. It is to be hoped that the program there advocated will be carried on as happily as it has been begun, for such an enterprise requires continued attention. As conditions and personalities change, the flow of ideas between college and school must be continually renewed. The student should have, in high school, opportunity to sample various types of work, that he and his instructors may analyze his powers in diverse lines. Much interesting work has been done in the field of specialized aptitude testing, to discover for what training and vocation the student is best fitted through natural aptitudes. Anything in this area is still somewhat experimental, though sufficient progress has been made to warrant tentative conclusions and guarded advice to the student. Mention should be made of the Thurstone Test of Primary Mental Abilities issued by the American Council on Education, and of the testing program developed at the Human Engineering Laboratory under the direction of Professor O'Connor of Stevens. Still more promising appears the Yale Battery of Differential Aptitude Tests, developed and refined through use over a period of years, for the specific purpose of giving educational and vocational guidance. Any of these tests are worth

further study in an attempt to find the best instruments for pre-college vocational guidance.

Significant to engineering studies are tests of spatial sense, such as those developed at Minnesota, at Missouri School of Mines, at Yale, and by the College Entrance Examination Board. In using such special tests, as well as other more general measures, it is important to consider all the evidence in any particular case. Serious errors may result from the attempt to advise from one set of measures alone, without considering other available indications. Guidance is best performed by a person adapted to the work by interest and training. Such a person, winning the confidence of the student, may get the student into the right line with a minimum of friction. Equally important, he may help the student to iron out certain quirks and oddities which are interfering with the efficiency of his efforts.

Adapting the Curriculum to the Student

In view of the wide range of abilities among students admitted to many of our engineering colleges, it is not surprising that failure has generally attended the efforts to force all students to conform to a common pattern of instruction. On the other hand excellent results have attended efforts to segregate students in various ways according to training and ability, when the instruction has been varied also to suit the needs and abilities of each group. Provision of retarded or review courses may care for boys deficient in one or more units of high school subjects, as well as for those who show, on placement-examinations or in a quick review, that they are not qualified to proceed with the regular freshman course.

Failures in freshman mathematics have reached such a figure that one must picture an area of study too difficult or too extensive for the abilities and training of the students admitted.. On the other hand there is evidence that the common engineering curriculum contains more mathematics than is needed in most of the careers to which the graduates proceed. The situation raises a number of fundamental questions. Is it possible to set up a program of mathematics, planned for engineers as a tool subject, that will reduce the number of failures yet give the student all he needs for competence in engineering? What gain can be made in motivation, aroused interest, and increased efficiency of learning through a careful coördination of mathematics with other subjects of freshman instruction? How can these goals be achieved while retaining for the good student the opportunity to get all the mathematics that he can, perhaps even more than at present? I believe that these aims can be attained, in large measure, by a program of sec-

tioning according to ability, within the framework of the regular freshman course. Using results of placement examinations and the records of students in high school, it should be possible to assemble a group who can take all that the mathematicians feel impelled to give; most of these students will welcome the opportunity. Another group can be segregated, too good for review work, yet not equal to mathematics for mathematicians; by selection of material and careful presentation of mathematics for use, it should be possible to give these boys all that they require for further study. Two or three grades of section will certainly suffice. If two or three sections can be scheduled at one time the progress for the first month or two will hardly be differentiated enough to preclude readjustment of the boy who is evidently misplaced.

Significant results have been obtained from such a program when it is planned to give the better student the incentive and opportunity for work of high quality, to the poor student the chance to advance at his best pace. Evidence as to the effectiveness of this procedure is hard to get. Opinion is almost universally favorable, where the attempt has been carried through with graded sections and graded instruction. There is a little direct evidence, where comparison with ungraded sections of equal ability is possible; and this evidence is all favorable. The practice has been carried out successfully in most subjects of the first two years of engineering.

What of further progress for these students? Can boys from different sections, covering different material, be treated alike in later courses? Surely under the old style of ungraded sections boys coming to later engineering courses are not equally proficient in mathematics. Is it better that the poor student shall have a smattering and incomplete understanding of the whole realm covered by the good student, or that he shall have a fairly complete mastery of certain selected topics, those that seem absolutely vital to further study? May it not be possible to grade students not entirely on their mastery of a fixed realm, but partly on the extent of the realm over which they have achieved a high degree of mastery.

Many students find that much of the work in the first two years is disappointing, in that it does not seem to be engineering, but is too theoretical. Others are discouraged because they do not feel real progress toward a desired end. Where steps are taken to make the work appealing to the student, and to let him feel that flavor of engineering which is so important, motivation is improved and student morale is greatly stimulated.

How are we to estimate the success of these various programs of instruction and adjustment? How can we place properly an

applicant for advanced standing? How can the Junior College, for example, compare its results with the corresponding years of engineering school? The answer to these and other questions may be found in the use of universal tests, used on a nation-wide scale. Fortunately there are already tests available in certain subjects of the engineering curriculum, the tests for college students of the Co-operative Test Service in English, Chemistry, Mathematics, and Physics. Though these tests do not fit precisely the curriculum at any one institution, they are broad enough in their coverage of the area of instruction so that a student may expect to find scope for the display of his powers in that field. With national norms and comparable forms, it is possible to compare successes of instruction in different years or at different institutions.

The tests of the Graduate Record Examination, for use toward the end of the senior year in college or at the inception of graduate study, offer a chance to measure the general background of knowledge and understanding in many areas. Students generally welcome the opportunity to take standard tests and learn their strong and weak points.

The Flexible Curriculum

Within the broad realm of technology are functions which are diverse and exist on many levels of responsibility. Some of them are in a high degree professional. Others are sub-professional or non-profesional in nature; some are scarcely to be distinguished from pure research, while others verge on commerce or finance. Diversity is, in fact, one of the basic characteristics of engineering services. . . .

Advanced training for the higher technical levels of engineering should be included in the general program of engineering Education but should not become its dominating aim.

Undergraduate curricula should be made broader and more fundamental through increased emphasis on basic sciences and humanistic and social studies. This will require greater efficiency in the use of the student's time to be gained by pruning to the essentials of a sound educational program (From the Report on Aims and Scope of Engineering Curricula).

With so much diversity in engineering services there appears to be need for greater diversity in engineering training. The usual program is far from approaching the high aims quoted, particularly in the emphasis on basic science and humanistic and social studies. There is real doubt of the capacity of the average engineering student of today to profit from such a program. On the other hand there are many who could profit to a high degree and would find a more useful place as a result of such training.

Perhaps there is need for three parallel courses in the field of technology, beyond the high school level: a two year terminal

course of certificate grade; our present four year engineering course leading to the degree of bachelor of science; a six year program, rich in basic science and mathematics, but with more applications and with a broader base in the humanities than is possible in a four year course.

The decision to pursue studies in the field of technology should be made as early as consistent with sound judgment, at the tenth or eleventh grade if possible, and the curriculum at the college level should be based on early training made possible by such a decision. Similarly the choice between the various options within the field of technology should be made as soon as it can be made wisely, if possible at the time of graduation from high school. In view of the present uncertainty in criteria available for guidance and selection, we must expect many wrong decisions. Thus it is especially important that, within the field of technology, the various curricula be differentiated as little as possible in the early stages. It may be well to sacrifice some features of an ideal teaching curriculum, in the interest of student re-adjustment after he has made a false start. There must be enough work of various kinds so that the student and instructor may know which of several options fit best the abilities and interests of the individual.

The technical institute, of which there are far too few, offers excellent facilities for the student who can see clearly, at the end of high school, that there lies his field of work. Similarly the engineering school offers an adequate program for the boy who belongs there, but the exchange between the two, for wrongly placed students, is far too difficult. and involves needless loss of time. A solution is offered at the Junior College, particularly as it has developed in California, where there are offered under the same roof courses of certificate grade and courses preparing for the last two years at the university. Preëngineering work there offered is accepted in the California Universities as quite the equivalent, for most students, of the first two years of engineering at the university. The change can be effected, from preëngineering to certificate course or the reverse, with little loss, far less than is involved in a change between two separate institutions.

Despite this example of success, there is apparent in some quarters a rather strong feeling that the two year terminal course does not belong on the same campus and under the wing of the engineering school. Some fear that the presence of an easier course will degrade the regular engineering curriculum. This springs from the idea that the two year terminal course is designed for those who cannot do the regular engineering work, that this course is a cut below the four year program. Should we not, instead,

think of three different kinds (not degrees) of abilities: the technical, the engineering, the scientific? It may be that the boy in the technical course cannot do engineering work; it may be quite as true that the boy in the engineering course cannot do technical work. Each has its own skills. There are several points that favor the three courses on the same campus. From the student's point of view, the change involves less loss of time, and can be accomplished without social readjustment or loss of face; the services of the same guidance officers and testing bureau are available; those in charge of each course are familiar with the work of the other and know what the student has done and how he can most readily adapt to the change. The graduates of these three curricula all belong in the field of technology; they will work together later; it is well for each to know as much of the other as possible. Exchange of ideas among faculties and student bodies should be encouraged.

In fulfilling our educational aims we must help the student to probe his own capacities when applied to various lines of study, or to explore several lines of effort as outlets for his own powers. With such guidance and training as we can give, we help him toward the fullest realization of his own potentialities, for the benefit of society and for his own personal satisfaction. Coördinate in that program are two functions—appraisal and improvement—so highly interdependent that it is hard to classify any single factor in the educative process as belonging exclusively to one or to the other. Our particular concern here is with appraisal—determining the assets and liabilities of the student or evaluating the raw materials available for molding and fabrication. Appraisal is without value unless it is possible to adapt the plan of fabrication to the recommendations of the appraiser. Guidance has no significance if there is not provision for the student to follow the advice given.

Summary

The first aim of a program of student selection and guidance should be to place each student in the curriculum best fitted to his own peculiar tastes and abilities, and to help him to work effectively in that curriculum.

As a basis of selection the rank in class in high school comes first, and is more reliable if the high schools are rated. Selected tests, of general aptitude and of achievement in specific subjects, can supplement records of high school performance, in selection and guidance.

A slight preference is indicated for the Psychological Examination of the American Council on Education and the tests in mathematics, science, and English issued by the Coöperative Test Service.

Even with the most careful selection there appears to be a need for graded sections in many subjects of instruction, and substantial gains are apparent from such practice, where the instruction is adjusted to the abilities of the class.

The work of the student may be rendered more effective by such adjustments, as well as by instruction that has due regard for motivation and by an efficient counselling service which will strive to correct mal-adjustments, both personal and intellectual.

For the work of such counselling service and for the selective process to be fully effective, there must be available somewhere a diversity of curricula, ranging over technical, engineering, and scientific courses.

Testing Agencies and Sources Mentioned

American Council on Education, 744 Jackson Place, Washington, D. C.
College Entrance Examination Board, 431 West 117th Street, New York, N. Y.
Coöperative Test Service, 15 Amsterdam Avenue, New York, N. Y.
Graduate Record Examination, 437 West 59th Street, New York, N. Y.
Human Engineering Laboratory, Stevens Institute of Technology, Hoboken, New Jersey.
Iowa—Bureau of Educational Research and Service, The State University of Iowa, Iowa City, Iowa.
Minnesota—University Testing Bureau, University of Minnesota, Minneapolis, Minnesota.
Missouri—Professor C. V. Mann, Missouri School of Mines, Rolla, Missouri.
Yale—Department of Personnel Study, Yale University, New Haven, Connecticut.

Approved by
W. A. Knapp,
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Gibb Gilchrist,
I. C. Crawford,
R. L. Sackett, *Chairman,*
Committee on Student Selection.

ON TERMINOLOGY AND SPECIFICATIONS FOR COMPREHENSIVE EXAMINATIONS IN ENGINEERING *

By R. H. FRAZIER †

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The interchange of ideas among those engaged in the development of comprehensive examinations has been somewhat difficult, owing to the lack of a generally accepted terminology for describing the components of the examinations, their aims, uses, and particular characteristics. This was pointed out by the writer at the 1937 conference of the Committee.‡ At the 1938 conference, Professor Mann presented a paper § that made a major step toward remedying the situation. The suggestions set down on the following pages include substantial borrowings from Professor Mann's ideas, but amplify those ideas somewhat and include a condensation in the form of a table as an aid in visualizing the relationships of the things defined and in stating specifications concisely.

The need for a closely knit terminology is of more fundamental importance as an aid to careful thinking than as an aid to writing and conversation, because ideas only loosely formulated cannot be accurately expressed. In the construction of comprehensive examinations, much study is needed to formulate them so as best to serve the situations *of which they become components.* The italics are to call attention to a rather common notion that an examination is a sort of measuring instrument that can be inserted without creating any disturbance by its presence, and thus give an indication of the state of affairs as if the instrument did not exist. In physical measurements, for example the measurement of voltage, the selection of type and range of instrument must be made with due consideration of the circuit into which the instrument is to be placed, and even then allowance may have to be made for its presence. By analogy, substantially any examination produces an appreciable disturbance when introduced into the circuit; some so nearly short-circuit the mains that the reason for low voltage is almost entirely due to the presence of the instrument; others give deceptively high voltages which, if all the connections are traced, are found to represent the point of instructors' input and not the

* As presented at the 49th Annual Meeting, S. P. E. E. (Comprehensive Examinations), University of Michigan, June 23–27, 1941, with minor changes based upon discussion at the Conference.

† Chairman, Committee on Comprehensive Examinations, S. P. E. E.

‡ Discussion by Richard H. Frazier, JOURNAL OF ENGINEERING EDUCATION, Vol. XXVIII, pp. 368–9, 1938.

§ "Specifications for the Construction and Use of Comprehensive Examinations in Engineering Education," by Clair V. Mann.

point of students' output. An examination, therefore, should not be viewed primarily as a portable type of instrument that can be inserted indiscriminately when and where needed, but rather as an instrument built into the system whose presence influences the workings of the system, and whose indication must be interpreted in the light of that influence. Furthermore, since examinations do exert influence upon the workings of the educational system, they should be designed so as to render this influence educationally desirable rather than harmful. The extraordinary possibilities of so designing comprehensive examinations give them outstanding advantage over the usual scheme of term examinations. Therefore any aid toward drawing specifications for comprehensive examinations is important.

1. Preliminary on Terminology

The word *objective* as applied to examinations is generally agreed to mean that the examination should yield the same score regardless of the person who rates the answers. In contrast, the word *nonobjective* (or *subjective*) applies to examinations in which the judgment of the person who does the correcting influences the score, or mark assigned in evaluation of the achievement of the student as shown by his response to the examination. Comprehensive examinations may be of either type or combinations of both types.* In the paragraphs immediately following, preliminary definitions are given approximately in the order needed to use them in defining other words; some that do not apply to comprehensive examinations are given merely to exclude them from further discussion.

A *course* † is an instructional subdivision of a *subject* † ‡ (such as chemistry, mathematics) created for systematization, convenience, or expedience in teaching a portion of that subject in a term. Educational institutions commonly designate courses by letters or

* The original plan was that this paper should relate particularly to nonobjective examinations, and that a separate paper by Professor C. V. Mann and Dean W. C. White should set up terminology for objective examinations. After reading the draft of this paper, they expressed the view that so much of the terminology developed therein could be common to both types of examination, that their paper could take the form of a supplement. As a consequence of discussion at the Conference, and of subsequent correspondence, several changes have been made in this paper to remove its restriction to nonobjective examinations, and to lend it more readily to some expansion for objective examinations by a supplementary paper.

† *Course, subject,* and *curriculum* unfortunately have interchanges of usage from one institution to another, so any usage specified necessarily is contrary to established usage somewhere. However, either some usage must be adopted for comprehensive-examination terminology, or entirely new terminolgy must be invented.

‡ *Field* is sometimes used synonymously with *subject.*

numbers, such as "Chemistry B" or "Calculus 21," and define their scopes in the catalogue description.

A *curriculum* † comprises the entire series of courses leading to a degree or certificate.

An *examination* is an investigation directed toward one or more of the *aims* in a listing which follows in the next section of the paper.

A *comprehensive examination* is an examination directed simultaneously toward several of the aims and simultaneously toward several correlated courses in the same or in different subjects.

A *problem,* a *question,* an *essay,* or a *discourse* ‡ is an *element* of an examination. A *problem* is a situation proposed for solution, or an alleged solution of a situation proposed for verification. A *question* is a query of basic fact,—a query about basic definitions, rules, laws, or concepts. An *essay* § is a written discussion ‡ on a specified topic. A *discourse* ‡ is the oral counterpart of an essay.

A *project* is a problem of comprehensive scope.

A *term examination* relates only to one complete course. A *test* or a *quiz* relates only to a portion of a course. These distinctions are sufficient to place term examinations, tests, and quizzes outside the bounds of the work of the Committee, and make unnecessary more refined definition by the Committee.

An *exercise,* a *problem section,* or a *calculations section* is a device or procedure the purpose of which is to provide practice or training either with or without direct professional supervision. None of these is an examination, and hence none of them lie within the bounds of the work of the Committee.

General examination shall not be given status in connection with comprehensive-examination terminology.

2. Development of Pattern; More Terminology

Comprehensive examinations have two *types:*

A. Objective type,
B. Nonobjective type,

and may consist of combinations of these types.

Comprehensive examinations may be given at different *levels:* *

0. Entrance level,
1. Freshman level,

‡ *Discussion* and *discourse* have been interchanged since the Conference.

§ Perhaps provision should be made for distinction between a *restricted* and a *free* essay (or discourse).

* In order to provide for five undergraduate years in the curricula of some institutions, the Middler or Pre-junior level could be inserted as 2.5 or thereabouts. In fact the use of decimals to represent any mid-year or other inter-

2. Sophomore level,
3. Junior level,
4. Senior level,
5. Master's level,
6. Doctor's level,
7. Professional level.

The *scope* of a comprehensive examination may include the entire curriculum up to the level of the examination, or one subject up to the level of the examination:

a. Curriculum,
b. Subject.

Comprehensive examinations have several *styles:* †

I. Oral style,
II. Written style,
III. Laboratory style.

Each style of comprehensive examination has certain elements (previously defined) as shown in the following Table under (*a*), (*b*), (*c*), (*d*), (*e*); each element is directed toward one or more *aims:*

An investigation of the

[1] knowledge,
[2] accuracy under time pressure,
[3] understanding,
[4] resourcefulness, ingenuity,
[5] originality,
[6] self-reliance, mental courage,
[7] judgment,
[8] skill in expression,
[9] aptitudes,

of the examinee; and each element has one or more *uses:*

(1) to establish qualification for work at the next higher level,
(2) to provide a basis for honors and awards,
(3) to indicate competence along functional lines,
(4) to provide a basis for granting professional licenses,
(5) to provide a vehicle of instruction, especially for the correlation of subjects,

mediate level seems desirable,—more desirable than having some institutions operating on a scale of four levels and others on a scale of five levels within the undergraduate period. The number scale should relate to curricular levels, not to elapsed time.

† The word *form* has been suggested as an alternative for *style*.

(6) to ascertain the effectiveness of instruction, and so to guide instructional effort,
(7) to influence the mode of study,
(8) to establish standards.

The elements of a comprehensive examination may be administered by *outside examiners* * (nonmembers of the staff of the institution of the examinee) or by *inside examiners* * (members of the staff of the institution of the examinee):

o. Outside examiners,
i. Inside examiners,

and this administration may permit the use of any desired references, designated by *open book;* or may prohibit the use of references, designated by *closed book:*

y. Open book,
n. Closed book,

or may permit partial use of references.

The *duration* of a comprehensive examination or any *part* thereof is the time allotted expressed in days of eight working hours. Within any style those elements of the same kind constitute a *part* of a comprehensive examination.

The *specifications* for a comprehensive examination have been stated when the complete pattern, consisting of type, level, scope, style, parts, aims, uses, examiners, reference conditions, and durations, has been set.

These specifications can be stated in a condensed fashion by means of a chart or table.

3. Table

The pattern is summarized in the following table. By checking the proper numbers and letters in the table, and by filling in the numbers corresponding to the aims, uses, and durations, a comprehensive examination can be completely specified within the limits of the terminology proposed. The proposed terminology and table, however, are not intended to freeze the form of comprehensive examinations. The table can very readily be modified or extended to accommodate new styles, elements, and so on. The table forms merely the skeleton. It is useful in obtaining an over-all picture of the pattern of a comprehensive examination and in communicating the pattern to others. For example, a committee charged with

* A distinction perhaps more important than whether the examiner is outside or inside with respect to the *institution* is whether he is outside or inside with respect to the *course*. Provision should be made in the terminology to recognize this distinction.

TABLE

COMPREHENSIVE EXAMINATION: NONOBJECTIVE * *B*: LEVEL 0, 1, 2, 3, 4, 5, 6, 7

Scope *a.* Curriculum *b.* Subject — Style I, Oral					
Parts	Aims	Uses	Examiners	References	Durations (days)
(*a*) Question	[ ]	( )	o i	y n	
(*b*) Problem	[ ]	( )	o i	y n	
(*c*) Project					
(*d*) Essay					
(*e*) Discourse	[ ]	( )	o i	y n	

Scope *a.* Curriculum *b.* Subject — Style II, Written					
Parts	Aims	Uses	Examiners	References	Durations (days)
(*a*)	[ ]	( )	o i	y n	
(*b*)	[ ]	( )	o i	y n	
(*c*)	[ ]	( )	o i	y n	
(*d*)	[ ]	( )	o i	y n	
(*e*)					

Scope *a.* Curriculum *b.* Subject — Style III, Laboratory					
Parts	Aims	Uses	Examiners	References	Durations (days)
(*a*)	[ ]	( )	o i	y n	
(*b*)	[ ]	( )	o i	y n	
(*c*)	[ ]	( )	o i	y n	
(*d*)					
(*e*)					

Numbers or letters that apply to the desired pattern are to be encircled.
Numbers corresponding to the desired aims, uses, and durations are to be inserted.

Aims

[1] knowledge
[2] accuracy under time pressure
[3] understanding
[4] resourcefulness, ingenuity
[5] originality
[6] self-reliance, mental courage
[7] judgment
[8] skill in expression
[9] aptitudes
[10]

Uses

(1) to establish qualification for work at the next higher level,
(2) to provide a basis for honors and awards,
(3) to indicate competence along functional lines,
(4) to provide a basis for granting professional licenses,
(5) to provide a vehicle of instruction, especially for the correlation of subjects,
(6) to ascertain the effectiveness of instruction,
(7) to influence the mode of study,
(8) to establish standards,
(9)

o = outside examiners
i = inside examiners

y = references permitted
n = no references

* According to Dean White, a table similar to the written style section of this table could serve for objective examinations, or this table as it stands could serve if means were provided to show whether the parts of the written style are objective or nonobjective.

the formulation of a comprehensive examination might, on the basis of the experience and beliefs of its membership, draft by means of the table a master pattern that the examination should have in order best to serve the situation at hand. Copies of this pattern then could be distributed to those who are to fill in the details of the various parts of the examination in order to show each contributor the relationships of the parts and the particular aims, uses, and mode of administration of the parts for which each is responsible. More experience than has yet accumulated in classified form is needed actually to determine what elements best serve certain desired aims and uses, how these elements should be apportioned in the complete examination, and what the detailed characteristics of the individual elements should be. The use of the table or some similar device, in association with some appended comments upon the results of the examination, should serve to classify the needed experience as it accumulates.

In the slight revision of this paper for publication, most of the changes in terminology made or proposed have been indicated in footnotes and have not been made as final changes in the body of the paper. This plan was adopted in order to make the changes and proposals readily evident, and because no terminology can be considered final until sufficient opportunity has been afforded for criticism and suggestion based on study and trial usage. The writer wishes this paper to serve as a basis for such criticism and suggestion, and hopes to receive a wide response from workers in the field citing desirable changes, additions, or omissions, so that a closer approximation to unanimity may be reached at the 1942 Conference. The writer wishes to thank Professor C. V. Mann and Professor W. E. Howland of the Committee for reading the first draft, Professor Edward Bennett for suggesting some of the changes incorporated in the footnotes, and especially Dean W. C. White for criticisms, suggestions, and support during the entire year of association on the Committee.

APPENDIX

Alphabetical Arrangement of Definitions *

aim—a purpose of investigation by means of an *examination*.

course—an instructional subdivision of a *subject*.

closed book—an indication that no references may be consulted by a student taking the *part* of a *comprehensive examination* so designated.

* Omitting those stated merely for the purpose of exclusion. Italicized words within definitions are used in the technical sense defined elsewhere in the list.

comprehensive examination—an examination directed simultaneously toward several *aims* and simultaneously toward several correlated courses in the same or in different *subjects*.

curriculum—the entire series of *courses* leading to a degree or certificate.

discourse—the oral counterpart of an *essay*.

duration—the time, expressed in days, allotted to a *part* of a *comprehensive examination*.

element—a *problem, project, question, essay,* or *discourse*.

essay—a written discussion on a specified topic.

examination—an investigation directed toward one or more *aims*.

inside examiner—an examiner attached to the staff of the institution of the examinee.

level—an indication of the position in the educational system at which a *comprehensive examination* is placed.

nonobjective (or *subjective*)—a type of examination the score or grade of which is dependent upon the judgment of the person who does the correcting.

objective—a type of examination the score of which is independent of the person who does the correcting.

open book—an indication that any references may be consulted by a student taking the *part* of a *comprehensive examination* so designated.

outside examiner—an examiner not attached to the staff of the institution of the examinee.

part—an assemblage of *elements* of one kind.

pattern—a specification of *type, level, scope, style, parts, aims, uses, examiners, open* or *closed book,* and *durations*.

problem—a situation proposed for solution, or an alleged solution of a situation proposed for verification.

project—a *problem* of comprehensive scope.

question—a query of basic fact,—a query about basic definitions, rules, laws, or concepts.

scope—an indication of comprehensiveness with respect to *curriculum* or with respect to *subject*.

style—an indication of the manner in which the student is required to respond to the examination—for example, orally, in writing, or by performing laboratory work.

subject—a branch of learning, such as chemistry, mathematics.

type—an indication of independence or dependence of the score or grade from the person who does the correcting; that is, *objective* type, *nonobjective* (or *subjective*) type.

use—a service an examination is expected to render.

PRESENTING THE CASE FOR THE TECHNICAL INSTITUTE *

By PARKE R. KOLBE
President, Drexel Institute of Technology

It is impossible to approach this subject intelligently without some slight review of what has been said in the past regarding the technical institute. Strangely enough these institutions have said little or nothing about themselves. They have never, in so far as I know, tried to develop their own academic solidarity by the formation of an association, nor even by the definition of their function in the technical world. To the engineering college teachers and to the surveyors of engineering education has been left the task of speaking for them. For example, Charles F. Scott of Yale stated in 1934:

> The situation in industry warrants a great expansion of technical education above the present level of the secondary schools. There should be a greater diversity of technical education to serve a wider variety of individual and industrial needs. To maintain but one type of school (the engineering college), and to ask it to meet all purposes is to invite blurring of aims and compromise of standards. The need is for schools having more definite purposes and more clearly visualized aims.†

A few years earlier O. W. Eshbach, now Dean of Engineering at Northwestern, said in his Survey of Adult Technical Education in the New York Industrial Area:

> It is felt that the development of our degree-granting institutions has so overshadowed all other forms of technical education that undue prominence is given to the four-year curricula. This situation cannot be corrected or other forms of technical education developed unless there is a change of viewpoint, both industrially and socially. A more general acceptance of the idea of education for the sake of acquiring useful knowledge and skill, rather than the acquisition of an academic degree is needed; also a closer coöperation between employers and educators in the establishment of programs of instruction helpful to the employed.

It is a striking fact that everything which the arbiters of engineering education have ever said about the technical institute has

* Presented at the 49th Annual Meeting, S. P. E. E. (Technical Institutes), University of Michigan, June 23–27, 1941.

† From the Summary of Results of the Investigation of Engineering Education and Related Activities (1922–1933), by Charles F. Scott, Chairman of the Board of Investigation and Coördination, published by the Society for the Promotion of Engineering Education, 1934, page 27.

been favorable. But with it all, they have unanimously failed to recognize it as an integral part of the system of engineering education. As a result the technical institute graduate finds himself faced by several unfortunate conditions which have an adverse bearing upon his future career:

1. His particular type of school has no form of inter-institutional organization and the only committee which speaks for the whole engineering profession and is active in separating the sheep from the goats in the technical world is for the present at least interested in engineering colleges alone.

2. State Licensing Boards seem to regard him as rather small fry or they ignore him utterly, and his road to an engineer's license is a long and difficult one.

3. The U. S. Civil Service Commission does not allow him to try for certain positions which would be open to him if he had spent his two years at a standard four-year engineering college.

4. By the nature of his course he is virtually shut off from continuing his work for a degree in a standard engineering college without great loss of time, *i.e.*, his course can rarely be adjusted so that he may receive a degree in two additional years. Truly the name "Terminal Course," so often applied to offerings of the technical institute has taken on a sinister significance. Can anyone wonder that there has been a tendency on the part of a few technical institutes to become full-fledged engineering colleges and thus put on the mantle of respectability?

The reasons for the present plight of these institutions are clearly explained by Professor Scott in the summary mentioned above:

> A lack of solidarity among the existing technical institutes has held back the development of similar schools over the country at large. Each institution has grown up around some local situation or some individual's vision, but with little sense of aims in common with other schools. Their heads have wisely sought to preserve this individuality. The result has been an emphasis on points of dissimilarity, amounting to a spirit of mutual aloofness. Thus separated, they have been unable to create a recognized status of their own. They were too often known as non-this or non-that to impress themselves on the consciousness of the country, much less its imagination. Their faculties suffer from a sense of professional isolation. There was no forum for their common problems and no organization for a united initiative.
>
> Technical institutes have been handicapped by the fact that their graduates received no educational credentials which are nationally recognized. The temptation has been strong to become colleges and award degrees. British educational authorities and professional societies have met a similar problem most effectually through the establishment of National Certificates, National Diplomas, and Certificates in Technology awarded by central bodies.

During the early period of the activity of the Engineers' Council for Professional Development, the Association of Urban Universities petitioned that body to include in its study of engineering colleges a parallel study of technical institutes with a view to possible future accrediting. The petition was declined in view of the magnitude of the task already undertaken, *i.e.*, the examining and accrediting of the engineering colleges of the entire country. No further action was undertaken in behalf of the technical institutes for several years. Finally on February 8, 1940, a dozen of these institutions sent representatives to a meeting at the University Club in Pittsburgh, called for the purpose of laying plans for securing a recognized place in the field of engineering education. The meeting was attended also by F. L. Bishop, Secretary of the S. P. E. E., President Doherty of the Carnegie Institute of Technology, Dean Potter of Purdue and Dean Hammond of Pennsylvania State.

As a result of this meeting, a petition was addressed to the S. P. E. E., asking that a separate section for technical institutes be formed within the framework of that organization. This petition was granted at the Berkeley Convention. A second petition was addressed to the E. C. P. D., asking that the Committee on Engineering Schools undertake a survey of technical institutes and present suggestions for some form of national recognition. This petition was also granted and a sub-committee appointed. Up to the time of this writing this committee has taken no action. Such, briefly, is the history of the movement for the recognition of the work of the technical institute. Needless to say, in spite of delays and slow progress, this movement is still very much alive.

Perhaps the main difficulty in the way of studying and classifying the work of technical institutes lies in the great variety exhibited by these institutions. Certainly no standard pattern exists, either in type of work nor length of course. They vary from courses lasting only a few months to more serious programs equivalent to two or more years of full-time work. Some are devoted to a single, highly specialized field of technology. Others offer a general engineering training on a foundation of the basic sciences. Some operate during the day, others at night only, and some both day and evening. Most of them are largely local in attendance and thus are but little known outside their own immediate neighborhood. These conditions are largely responsible for the fact that no nation-wide consciousness has ever been developed among them.

To define a technical institute is difficult—perhaps impossible. However, several attempts have been made. I shall quote a few: "A Study of Technical Institutes," published by the S. P. E. E. in 1931, says:

The key term is the common designation "technical institute" for all post-secondary technical schools giving more intensive instruction than the four-year colleges. This category, as used in this report, does not include trade schools which train for manual crafts nor junior colleges which offer only the introductory half of a complete college course. The ground covered herein relates only to terminal courses, of a content equivalent to one or more full academic years and, while more purely technical than the courses of the engineering colleges, including a substantial treatment of the underlying sciences, drawing and usually some work in English and economics.

The following types of courses may be distinguished, (1) "engineering" courses which parallel the college courses in more intensive and practical form and cover one, two or three years or their equivalent; (2) "technological" courses related to specific branches of industry, such as textile manufacturing, printing, engraving, bituminous coal mining, etc., and (3) "functional" courses, preparing for particular types of activity such as quantity surveying, textile designing, power plant management, etc. Correspondence, extension and evening courses have been included, though not comprehensively, where the total content equals at least that of a full academic year.

This is perhaps the best and most comprehensive statement available, but it is a description, rather than a definition. Another definition, suggested at the Pittsburgh meeting is:

Technical institutes offer briefer and more intensive programs of study than engineering, degree-granting colleges, and ordinarily devote less time to basic sciences and the humanities.

Finally we may ask, just what useful purposes do technical institutes serve, which are not served by the engineering colleges? Primarily, of course, they offer in evening sessions an opportunity for training to those who are employed in the daytime, and generally to those who could not afford a longer course. They lead to many technical positions in industry where a full college training is not required, and they offer opportunity to their more gifted graduates to ascend to even the highest positions. For the employed person the technical institute evening session often furnishes the opportunity to take courses related to his work, thus enabling him to improve his position. Then some evening sessions furnish a dignified opportunity for the older man to continue his studies, free from the embarrassment of association with adolescent youth only, since the average age of the evening student is considerably greater than that of the college undergraduate. Above all perhaps, the technical institutes furnish to industry an important source of trained employees, and thus fill a need which the engineering colleges alone are unable to meet.

The most important problem facing the technical institute today

is that of proper recognition of its graduates or, to express the same idea in more general terms, the problem of securing a nationally recognized status in the world of engineering education. The foundation of this new Section of the S. P. E. E. is the first important step in this direction. What is the next move? If the E. C. P. D. carries out the study of technical institutes with which it has been charged, and if it can establish some acceptable basis for giving national recognition to technical institute graduates, our purpose will have been accomplished. If not, the obvious recourse is the formation of an Association of Technical Institutes, perhaps identical with this section of the S. P. E. E., which will set up its own standards for membership and thus act as an accrediting body in the same way as many organizations of professional schools already function. This should be done, however, in closest coöperation with the E. C. P. D., so that engineering education may serve society as a unified whole.

In closing I should like to emphasize, even at the risk of repetition, just what such a unified organization should seek:

First—A closer definition of the term "technical institute" as a basis for membership and accrediting.

Second—A status for its graduates which will be nationally known and accepted by industry.

Third—Recognition by the Civil Service of the equivalency of its work in positions requiring less than college graduation.

Fourth—Realization by the State Licensing Boards for Engineers that graduation from a technical institute deserves at least some recognition in the requirements for State licensing.

And here I think I may rest my case with full confidence in the wisdom and energy of those who bear responsibility for the future of the technical institute.

INSTRUCTION IN INDUSTRIAL RELATIONS *

By JOHN W. RIEGEL

Director of Bureau of Industrial Relations, University of Michigan

Three major problems exist in the field of industrial relations. The first is to maximize the productivity of employees through better management of them and their efforts. The second is to distribute the joint income of industrial organizations among their members, namely to individual stockholders, managers and employees. And the third is to develop forms and procedures of industrial government which will be humane and preserve the integrity of the individual employee.

Most engineering graduates, I believe, are employed in business organizations, and a substantial percentage of them eventually take over administrative responsibilities. Many engineers in their careers first deal with material and mechanical problems, but later their work becomes increasingly administrative in nature. An analysis of administrative and staff positions indicates unmistakably that persons in them need to be able to work well with superiors, associates and subordinates.

Accordingly, it is fitting to suggest that engineering schools require their students who look forward to administrative work to consider a selected series of labor relations problems toward the close of their course. The series should aid the students to learn better, from their experience, how to deal successfully with labor problems in a social system characterized by private enterprise, freedom of labor, and political democracy.

Turning now to the objectives of instruction in industrial relations, we may mention first the need that the student has for appreciating the complexities of problems in the field, and the fact that many times he must go forward and make decisions without complete knowledge. For this reason, the student should appreciate that his margin of error in dealing with labor problems is always going to be high; that the evidence is never all in; and that he must constantly keep his mind open for reception of new evidence.

Furthermore, the evidence is not of an objective sort. The administrator must be guided by personal observations, looks and manner, silence and speech, and by reports of others' observations. He has to become sensitive to many subjective sources of information and impression.

* Presented at the 49th Annual Meeting, S. P. E. E. (Labor Relations), University of Michigan, June 23–27, 1941.

Another thing the student must learn is the importance of individual variations in the aptitudes, skills, and temperaments of his superiors, associates, and subordinates. It is literally true that people do not "add up." One is not exactly like another in any particular. The truth is that the qualitative aspects of most labor problems are highly important. Each person is like a new alloy or compound, which first has to be understood before being dealt with.

To be sure, general policies and aims affecting employees are geared to what managers consider to be typical people, and yet the administrator knows that in any real problem, he never deals with typical people, but always with individuals having particular qualities.

The third thing that the student should appreciate is that each individual in a business organization has his own personal interests and problems, and that many of these are not concerned with the business itself. Materials, machines and solutions do not present such complexities; they can be manipulated; and they do not have interests of their own, or aims of their own, which they wish to pursue. Fledgling administrators do well to recognize that each employee has personal interests and problems, and that the whole employee, including these complexities, has to be managed, and that, in managing him, regard must be had to them.

A fourth thing for the student to appreciate is that the potentials of individual people and organizations are not definitely known. We cannot tell precisely what the limits of performance are, either to the individual or to the organization. Consequently, a considerable latitude exists for the administrator to serve as a leader. Employees, in other words, do not have fixed qualities, and in groups, they work well or poorly, depending upon some few known and doubtless many unknown variables.

Still another thing for the student to appreciate is the existence of emotional conflicts within employees. The desires of individuals for self-expression and self-expansion often run counter to the needs of the organization, which require them to subordinate themselves to some general purpose. Frequently, organization changes interfere with ambitions, status, and prestige, and thus generate personnel problems. Then, too, there are the emotional conflicts generated by desires for security in a world of technological change and political instability.

Another lesson to be learned by the student is the importance of sentiments and convictions common to members of a group. These are operative upon all of us, even though some of them are irrational. The managers, for instance, have their folk-ways, just as do professors or the employees in a given craft. These common

sentiments govern individual conduct. Sometimes, for instance, they dictate that earnings on a given job should be about so much. Then the individual employees are constrained by their desire for group approval to refrain from earning any "excessive" bonus.

It is particularly desirable that students, whose courses are so largely scientific in nature, should appreciate the importance of prejudices among humans. Because of the limits of personal experience in a tremendously complex world, each of us is well informed in some things and grossly ignorant in others. Yet we tenaciously hold opinions and have attitudes on matters not within the range of our experience. A young man in business who assumes that he and his associates are entirely rational, and therefore can be influenced readily by rational appeals and arguments, is working under a delusion. One of his problems is to learn how to sense and deal with prejudices.

Furthermore, he should understand something of the strategy of negotiations and see that partisan agencies exert pressures and try to coerce other groups into the granting of concessions; he should see that these groups are constantly maneuvering to build up their resources and power, and that they seldom regard the common interest in pursuing their own immediate desires. He should study balances of power as being a necessary means of maintaining working relationships between pressure groups.

It is of the utmost importance that the student appreciate that there is harmony as well as conflict in the economic interests of investors, managers, and employees. Only partisan doctrinaires have simple solutions for the economic problems which arise out of the labor relationship.

Another significant fact which the student should note is that top managers, sometimes owners, constantly manage through agents. Top management seldom deals directly with labor problems; they are dealt with by superintendents and foremen. Top management in a number of cases has not adequately instructed these agents.

Then, too, the student should see that labor problems are affected tremendously by variables outside the plant, for which management has no responsibility. An employee's life and experiences off the job certainly condition his fitness, willingness and behavior as a worker.

It is particularly important that engineering students, whose discipline so largely concerns itself with material and measurable forces, come to appreciate that, when they join a business organization, they are face to face, so far as the human and social factors are concerned, with the factors just outlined.

Now, turning to specific ways and means, we can suggest that a

sequence of courses in industrial relations for the engineering student or student of business administration can well occupy 180 class hours. The subject matter will be arranged by different instructors according to their interpretation of the problems in the field, but some investigation of these courses shows that the following topics designate major sections of the instruction:

1. Employee attitudes and conduct. These are analyzed in selected case studies.

2. Factors affecting labor productivity; these include natural resources, personal freedoms, social institutions, mechanization of process and the application of mechanical power; they include also hygiene, education, and the role and methods of government.

3. The essentials of personnel management and conservation, including such topics as the delegation of duties and responsibilities, coördination of positions; provision of facilities; development of improved methods of work; selection of employees; development of manual, clerical, and managerial skills; administration of production standards; wage and salary adjustment; elements of supervision; the prevention and relief of employee risks; expansion, contraction, and readjustment of workforce; and endeavors to bring about company-wide understanding of policies and procedures.

4. The development of industrial government. Here reference is made particularly to sections of collective agreements which set forth the rights of employees and the procedures of management in such matters as layoff, reëmployment, discipline, adjustment of grievances, appeals in cases of discharge, pay adjustments when operating conditions are not maintained, etc. In its broadest sense, this section deals with the sharing of control of the shop.

5. Collective bargaining on economic issues and on basic economic questions.

6. The bearing of labor legislation upon industrial operations. In this section there is a treatment of the National Labor Relations Act, the Wage-Hour Law, the Social Security Act, and the older regulations affecting working conditions, accident compensation, and hours of work.

7. A few courses present also a worthwhile discussion of managerial responsibilities and relationships which bring to the student some of the problems which he will encounter as a member of a managerial group, wherein the decisions and operations of each individual have to be well coördinated with those of other individuals.

8. Finally, the instruction presents some essentials of labor policy as taken from the published statements of leading American corporations. Thus, after a detailed examination of problems in the field, and the complexities of managerial work, there is a state-

ment of long-range aims to be achieved in the field of employer-employee relations, from the managerial point of view.

With this range of subject matter before us, the question of teaching method arises. Different instructors naturally will use different methods. It is common for them to use well-selected readings to present background information to the student. Some instructors depend primarily upon case-problems for instruction in critical and constructive thinking in this field. Most of these problems are reports of actual labor situations which called for managerial decisions and action; some present questions from employees' or unions' points of view. The problems confront the student with issues that commonly arise in the employer-employee relationship. Thus he is required to think about these problems and he sees the several interests involved, the importance of particular action as constituting a precedent, and the probable consequences to the company and employees of various solutions that might be adopted. This exercise in the analysis and discussion of labor problems develops abilities and increases understanding.

To summarize: instruction in industrial relations should give students a background of knowledge about labor problems; it should increase their interest in those problems; and develop some degree of sensitivity on their part to signs of employee dissatisfaction and maladjustment. It should illustrate how well-managed companies deal with a selected series of common issues which arise in the employer-employee relationship. But previously the students should be required to think their way to these policies and practices. The instruction would be less valuable if the students were merely informed with reference to these matters, for then the emphasis would be upon subject matter, whereas the true emphasis of the course should be upon the development of abilities and appreciation. The instructor should lay down a foundation for self-education in these matters by the students after they leave school. He should try to dispel prejudices which would interfere with their understanding of actual problems which will arise in their associations with fellow employees and managers.

The student of industrial relations comes to see the difference between the development of a plan and its translation into achievement. It is in the translation of plans into achievement that the human factor is really important. The student engineer thus learns to appreciate that the realization of his plans will depend largely upon his ability to lead and supervise his fellow men; to inform them and motivate them. The sooner he can develop successful and acceptable methods of managing people, in addition to being able to formulate plans, the sooner he will attain his full stature as an engineer who can carry a project from conception to completion.

REPORTS OF CONFERENCES *

AERONAUTICAL

John D. Akerman, Chairman of the Aeronautical Committee, asked Alexander Klemin of New York University to take the chair.

The following papers were presented:

M. J. Thompson, University of Texas, Austin, Texas, "Evolution of Aeronautical Engineering Education."

Alexander Klemin, Daniel Guggenheim School of Aeronautics, New York University, "What is Education in Aeronautical Engineering?"

John D. Akerman, University of Minnesota, "Future Prospects for Employment of Aeronautical Engineers."

L. R. Parkinson, North Carolina State College, "Airport Design and the Teaching of Airport Design."

George H. Tweeney, University of Detroit, "Airline Transportation."

This was the first meeting of the Aeronautical Committee of the S. P. E. E. and there was an excellent attendance, bringing representatives of many educational institutions. Coming to the conclusion first, it was very definitely the opinion of the group that the Aeronautical Committee of the S. P. E. E. should continue to function permanently. While no definite program or recommendations were made at the meeting, Professor Akerman was instructed to proceed energetically with the formulation of plans for other meetings.

A striking feature of the meeting was the very favorable reports of employment of graduating students. Students graduating in aeronautical engineering had as many as two or three offers of positions and almost none were left unplaced. It would appear that such a favorable employment situation will persist during the national emergency though there may be some surplus of aeronautical engineers after the emergency.

In the discussion of the paper on airport engineering, it was apparent that airport engineering and design were mainly in the hands of the U. S. Corps of engineers and experts of the Civil Aeronautics Administration but that nevertheless there was room for people to be trained in airport engineering, who might be of service to municipal authorities, contractors, consulting engineers, etc.

* 22 conferences held at University of Michigan, June 23–27, 1941; 18 reports received October 6, 1941, 4 missing.

Felix Pawloski of the University of Michigan gave an interesting historical apercu of the history of aeronautics. Long before the first great war, Professor Pawloski conceived the idea that aeronautical engineering might be taught in our universities. He wrote a number of letters to college authorities. It is extraordinary to recall that most of them replied in facetious vein rather thinking that there was no aeronautical engineering instruction possible. The meeting felt what a tremendous contrast there was between the early situation and the situation today.

There was a rather interesting discussion on why aeronautical engineering is not taught in many important schools of engineering such as, for example, Yale Sheffield and the College of Engineering of Princeton University. Dr. Dudley of Yale thought that in order to give the proper instruction in aeronautical engineering, it was necessary to make a real investment in laboratories, special staff, etc. and that unless an investment of this kind were made, it was probably better for schools to stick to their basic fundamental conceptions and send men for aeronautical instruction to those universities that had specialized in this new branch of engineering.

There was much discussion as to what should constitute an option in aeronautics for those schools which did not want to offer a complete course of instruction in aeronautics. Such an option would probably be most suitably placed within the Department of Mechanical Engineering. The option would probably begin with fundamental aerodynamic steps which might be of interest to mechanical engineers as well and might gradually develop into a complete course as circumstances dictated. It was felt that probably too many full courses of aeronautical engineering were being started and an institution which merely had an option was probably on much safer ground.

J. D. AKERMAN, *Chairman*

CHEMICAL ENGINEERING

The conferences of the Chemical Engineering Division included three regular sessions, a joint meeting with the Mathematics Division, and a special conference on National Defense as well as the regular luncheon business meeting. The general topics considered in each meeting were as follows:

Monday Morning: Joint session with Mathematics division—The Mathematical Needs of Chemical Engineers and How They May Best Be Met—R. S. Burington (Case) presiding.

Monday Afternoon: Service Courses Given by Chemical Engineering Departments for Non-Chemical Engineering Students, Division Chairman, J. H. Rushton (U. of Va.) presiding.

Tuesday Afternoon: Thermodynamics, Division Chairman, J. H. Rushton (U. of Va.) presiding.

Wednesday Morning: Round Table Discussion, Defense Training Courses in Chemical Engineering.

Wednesday Afternoon: General session, Past Chairman, J. H. Koffolt (Ohio State) presiding.

The dinner meeting was held jointly with the division of Cooperative Engineering, with the ladies as guests. The speaker of the evening was C. F. Kettering, Vice-President, General Motors Corporation, in charge of research. In his own inimitable, humorous manner Dr. Kettering related his experiences with young engineers just out of college and called for a more practical type of engineering instruction.

All meetings of the division were well attended, the largest group being the Tuesday afternoon meeting on Thermodynamics at which 93 were present.

One of the outstanding features of the meeting was a photographic exhibit of Chemical Engineering Laboratory Equipment supervised by R. C. Kintner (Ill. Tech.) with twenty-five colleges and universities contributing over 200 photos. The exhibit proved to be valuable means of exchanging ideas for improving our laboratories.

The average attendance at regular sessions was approximately 45 delegates. A total of 41 institutions were represented at the conference.

Papers and Discussion

Monday Morning: The Mathematical Needs of Chemical Engineers and How They May Best be Met (joint meeting with Mathematics division).

C. W. Borgman (Ch.E.) and C. A. Hutchinson (Math.—U. of Colorado), Analytical Methods.

J. W. Greene (Ch.E.—Kansas State), Graphical Methods.

T. K. Sherwood (Ch.E.—M. I. T.), Undergraduate Mathematics for Chemical Engineers.

G. E. Moore (Math.—U. of Ill.), Mathematics for the Chemical Engineer.

R. V. Churchill (Math.—U. of Mich.), Model Theory in Heat Conduction.

C. C. Torrance (Math.—Case), The Teaching of Advanced Undergraduate Mathematics to Chemical Engineers.

In the absence of Professors Borgman and Hutchinson, their paper was presented to the conference by C. O. Miller (Ch.E.—Case). The necessity of emphasizing *"understanding"* rather than *"problem solving"* in the early courses was pointed out. The student must also become "dimensional-conscious" so that he will have the proper regard for engineering terms and units.

In discussing the subject of Graphical Methods J. W. Greene (Ch.E.—Kansas State) first surveyed the various methods available for graphical differentiation and integration, after which the use of logarithmic, semilogarithmic and triangular graphs were reviewed. The construction and use of alignment charts and nomograms was next considered and it was agreed that these short cuts should be incorporated into the course, only after the basic theory had been well covered.

In the round table discussion which followed, R. S. Burington (Math.—Case) expressed the opinion that graphical methods should be used more extensively in connection with the study of logarithms. J. W. Cell (Math.— N. C. State) emphasized the need for a graphical section in each mathematics course, and suggested that a separate course in graphical methods and curve fitting be made a part of the curriculum. F. C. Dana (Math.—Iowa State) J. H. Weaver (Math.—Ohio State), and H. L. Olin (Math.—Iowa) also contributed to the discussion.

The viewpoint of the practical engineer was presented by T. K. Sherwood (Ch.E.—M. I. T.) when he expressed the view that mathematics must be a tool for the engineer to use and not an abstract course. With engineering problems of a professional nature, the difficulty usually arises in expressing the problem by means of a mathematical equation, the solution of the resulting equation usually being relatively simple. This being the case, it was suggested that "application" courses be given in the department of chemical engineering.

The theme of the general discussion which followed was that expressed by H. A. Curtis (Missouri) who called for the development of the viewpoint (especially in Design Courses) of Mathematics as an aid to the chemical engineer, which does not necessarily give absolute results.

C. A. Mann (Ch.E.—Minnesota) suggested that a mathematics application course be given concurrently with the unit operations. In this connection it was pointed out by Prof. Sherwood that a background in chemical engineering is necessary in order to apply mathematics intelligently to a given process. Applied mathematics courses, for this reason, are usually placed in the senior year.

The first speaker of the mathematics division, G. E. Moore (U. of Ill.) reviewed the contents of a course given to beginning engi-

neers in which practical problems were stressed along with mathematical principles. The results of the course indicated an increased interest on the part of the student which was reflected in better scholarship.

C. C. Torrance (Math.—Case) next presented two concrete problems of interest to chemical engineers and proceeded to solve these by new methods. The first problem dealt with the calculation of "entropy" in thermodynamics, while the second was concerned with the use of unit vectors along the "x" and "y" axis to express complex variables instead of the customary $\sqrt{-1}$. While there was considerable disagreement as to the practicability of the concepts presented, the paper of Prof. Torrance opened new avenues of thought for these subjects.

In his paper, Model Theory in Heat Conduction, R. V. Churchill (Math.—U. of Mich.) pointed out that in heat conduction problems, a set of transformations of variables in the differential equation for boundary conditions can be used to show the relationship between temperatures at corresponding points of any two geometrically similar solids of the same material, subjected to similar initial and surface temperature conditions.

Monday Afternoon: Service Courses Given by Chemical Engineering Departments for Non-Chemical Engineering Students.

A. H. White (U. of Mich.), Engineering Materials.
C. A. Mann (U. of Minn.), Chemistry and Engineering Materials.
R. N. Shreve and J. C. Lottes (Purdue), Chemistry of Engineering Materials.
L. K. Herndon (Ohio State), Engineering Chemistry.
D. J. Mack (U. of Tenn.), Elementary Engineering Metallurgy.
H. J. Masson (N. Y. U.), Engineering Metallurgy.

At the outset of his paper A. H. White (U. of Mich.) asked the question, "Are Service Courses a nuisance to be eliminated whenever feasible, or are they desirable features in any engineering curriculum?" It was then pointed out that all courses such as English, mathematics, drawing, physics and chemistry when taught to a student not majoring in that field must be considered as service courses, and for purely economic reasons, if no other these cannot be eliminated. However, it was agreed that service courses should be given only when one department has a superior knowledge and experience in a particular field and not because tradition has placed it there. An outline of the work as presented at the U. of Michigan was included.

C. A. Mann (U. of Minn.) observed that the problems most often submitted by practicing engineers (other than chemical engineers) revealed that these men did not possess a simple knowledge of chemical facts which in most cases would have solved the problems. An outline of subject matter for a course in the chemistry of engineering materials was presented and a proposal made that chemical engineering departments offer this course to all engineers.

It was emphasized by R. N. Shreve and J. C. Lottes (Purdue) that all engineers should possess a knowledge of engineering materials because new materials of construction are being proposed daily and it is necessary to know about these as well as the older alloys and materials such as cement, rubber, etc.

In presenting this material emphasis must be placed upon the relationship of the chemistry of these materials to their properties as used in industry and not upon details of manufacture. Such a course, it was pointed out, would be especially useful to all engineers contemplating sales or consulting work.

L. K. Herndon (Ohio State) called to our attention the fact the present shortage of metals demands a knowledge of substitute materials. This is a vital problem for those engineers now being graduated. Next, the scope, objectives, teaching methods and laboratory work of a course in engineering chemistry were presented. It is believed that courses in the chemistry of engineering materials will do much to relieve the "sour taste" which most engineers have for chemistry, and make them conscious of its practical value.

In the absence of D. J. Mack (Tenn.) his paper was presented by R. M. Boarts (Tenn.). Because most engineering students regard all "service" courses merely as necessary evils along the road to graduation, it was observed, that the first job which the teacher must do is to convince the student that the course is pertinent and useful in his chosen field of work. The subject matter of a service course in metallurgy was next outlined, and particular attention was paid to acquainting the student with the literature of the field through question assignments which must be looked up in reference books, and through subscriptions to technical journals.

H. J. Masson (N. Y. U.) presented a detailed description of a service course in metallurgy including both lectures and laboratory.

In the discussion, it was pointed out by J. L. Bray (Purdue) that other engineers are seeking new tools because they now see chemical engineers competing for jobs previously held by others. J. H. Rushton (Va.) called attention to the films available at the Bureau of Mines on the subjects of "Chemistry and Engineering Materials." H. A. McCormack (Ill. Tech.) suggested that courses on engineering materials include a study of material specifications, which are needed if substitutes are to be recommended for use.

In general it was agreed that the present tendency is toward more chemistry for all engineers, even if it is necessary to omit the word "chemistry" from course titles in order to "sugar coat" the pill.

Tuesday Afternoon: Thermodynamics.

Robert York, Jr. (Carnegie), Thermodynamics for Undergraduates in Chemical Engineering.

V. C. Williams (U. of Va.), Thermodynamics for Undergraduate Chemical Engineers.

E. W. Comings (U. of Ill.), High Pressure Reactions.

D. L. Katz (U. of Mich.), Thermodynamics for the Graduate Student.

L. S. Kassell (Universal Oil Products), Thermodynamics and the Engineering Graduate—What He Needs and What He Knows.

Robert York, Jr. (Carnegie Tech.) discussed the relation of chemical engineering thermodynamics to the rest of the curriculum, the objects and philosophy of such a course, and included a description of one method of teaching the subject. It was recommended that the course follow the regular physical chemistry treatment, and include steady flow processes, compression of gases, refrigeration, chemical equilibria, fluid flow, and "heat balances" and their limitations. It was pointed out that in developing analytical ability and straight thinking thermodynamics is supreme. A list of problems was included.

According to V. C. Williams (U. of Va.) the prime endeavor of thermodynamics for chemical engineers is to create confidence on the part of the student in analyzing and handling problems which are of practical value. After presenting an outline of a two term course in thermodynamics for chemical engineers, a list of over fifty problems covering the fields of fugacity calculations, equilibrium, electrochemistry, solutions and miscellaneous process problems was included.

An elective course in High Pressure Reactions for second semester seniors was next reviewed by E. W. Comings (U. of Ill.). The purpose of the course is *not* to discuss the technology of commercial high pressure processes, but to study high pressure equipment, chemical equilibrium at high pressures, and the physical and chemical properties of reactants under these extreme conditions. A complete course outline and bibliography were included.

The three principle ideas expressed by D. L. Katz (U. of Mich.) may be outlined as follows:

1. The goal of college training is the equipping of men so that they are prepared to grow in their knowledge of principles and in the application of these principles to a branch of the profession.

2. Graduate thermodynamics does not necessarily need to present new principles, but should develop a thorough understanding of the basic ones.

3. Courses which apply a few of the principles to practical problems set the pattern by which other less familiar principles may be applied.

Several illustrative problems were appended to the paper.

L. S. Kassel (Universal Oil Products) reported that oral examinations given to prospective employees showed that many students were not well grounded in fundamentals. They seemed to be unable to interpret simple data from the standpoint of feasibility of a process.

Leading the discussion period which followed, G. G. Brown (Mich.) emphasized the fact that the object of any course should be to teach men not thermodynamics, and also offered the opinion that thermodynamics is more than just a branch of science, it is as a philosophy or a method of approach to solving problems. H. C. Weber (M. I. T.) offered the explanation that much of the confusion regarding thermodynamics arises from the fact that an attempt is made to cover too much ground. According to Prof. Weber, the thermodynamics student usually passes through three stages, first overconfidence, then dispair, and finally a true understanding of the subject.

A very spirited discussion involving some of the more technical phases of the subject was then started in which G. G. Brown (Mich.), R. York (Carnegie), J. H. Keenan (M. I. T.), and J. A. Goff (Penn) were the principal participants.

Wednesday Afternoon: General Session.

T. G. Dixon and G. F. Dixon (Pratt), 2″ × 2″ slides for Educational work.

F. M. Whitacre (Case), Explosives.

S. L. Tyler (Secy. A. I. Ch. E.), The Chemical Engineer in National Defense.

E. E. Randolph (N. C. State), Developing the Professional Viewpoint in Chemical Engineering Education.

R. A. Morgan (U. of Fla.), The Chemical Engineer and Labor Relations.

C. O. Miller (Case), Principles of Automatic Control.

J. D. Lindsay (Texas A. and M.), Industrial Control Instruments.

The use of the positive 35 mm. film to make 2 × 2 slides was demonstrated by T. G. Dixon and G. F. Kinney (Pratt Inst.). The development of projectors with increased intensity of illumination and high resolution film have made possible slides costing as low as five cents each for black and white and 12½ cents each for kodachrome.

F. M. Whitacre (Case) called to the attention of the meeting that "Explosives" courses being offered throughout the country differed greatly in content and in many cases were not worthy of the name. A complete outline of a course, including chemistry, specifications and drawings, metal components, loading, assembly, physical testing and safety was then presented along with references.

From a questionnaire sent out from his office S. L. Tyler (Secy. A. I. Ch. E.) estimated that the defense program would need approximately 44 per cent more chemical engineers than those already employed, and that a shortage of men was inevitable. Chemical engineers were told that it is their duty to ask for deferment in order to serve the needs of defense industries. Finally a plea was made for the professional attitude among young engineers.

E. E. Randolph (N. C. State) analyzed technical education from a four-fold viewpoint, namely that of the administration, the teaching staff, the student and the industry, pointing out the obligations of each to the profession.

In as much as the chemical engineer must deal with workmen in the plant, it was pointed out by R. A. Morgan (U. of Fla.), that he should become familiar with the Federal and state laws governing labor relations and working conditions. A thorough knowledge of these regulations would often prevent labor disputes and represent a savings to the plant.

After calling attention to the rapidly increasing use of automatic control equipment in the process industries, C. O. Miller (Case) enumerated the factors which determine whether a given installation will be easy or difficult to control. An explanation of the various "types of control" along with diagrams was given.

J. D. Lindsay (Texas A. and M.) then presented slides showing the principles involved in various types of instruments as well as applications and methods of installation.

Chemical Engineering Defense Conference

The purpose of this conference was to bring together representatives from industry, government and colleges, in an effort to determine what the demands of industry actually are, and how the colleges can best train men to meet these demands.

The first speaker, T. A. Boyd, General Motors, appealed for a proper attitude toward efficient research programs, and recited cases where efficient programs had been successfully promoted.

B. S. Taylor, B. F. Goodrich and Co., expressed the opinion that the greatest need would be for men to serve in a supervisory capacity. The increased production of synthetic rubber should require the services of a considerable number of chemical engineers.

Turning to the subject of personnel for the new explosives plants, L. E. Stout (Wash. U.) related the facts leading to the establishment of the training courses in Explosives offered at Washington U. with the aid of the Western Cartridge Co. A complete outline of both lecture topics and laboratory demonstrations was presented.

Dean Potter (Purdue) speaking for the U. S. Office of Education estimated that five thousand men would be needed in the munitions manufacturing and loading plants, of which only eleven hundred were now being trained. Colleges were admonished to select men for training who would be acceptable to government and industry and that these men should be trained for a specific job rather than given general courses.

W. W. Hodge (West Va. U.) explained the organization of defense courses in 13 West Virginia cities under the guidance of the University and presented statistics showing the type of trainee being reached and how trainees were being assimulated by industry.

The place of the unit operations course in the Defense Training Program was discussed by C. M. Knudson (U. of Denver) after which a course outline was offered.

It was the consensus that the colleges should work closely with the industries in their particular locality in order to render the best service.

Business of the Division

The business meeting was held following the annual luncheon on Wednesday, June 25th, 1941, with chairman J. H. Rushton (U. of Va.) presiding. Since the Secretary's report had previously been published in the Journal of Engineering Education, **31**, 279, 1940, the reading of the minutes of the Berkeley Meeting was dispensed with. The treasurer's report showed a balance of approximately fifty dollars in the treasury.

H. C. McCormack (Ill. Tech.) reported that the laboratory committee was inactive during the year immediately following the publication of the text book, Applications of Chemical Engineering, D. Van Nostrand, 1940. However, future activity is predicted as revision of the book is anticipated.

The Unit Process committee, R. Norris Shreve (Purdue), chairman, reported that a symposium on the Unit Processes was held at the Detroit meeting of the American Chemical Society, September, 1940, and that the papers were published in *Industrial and Engineering Chemistry*, **33**, 158–221, 1941. Another such symposium is to be held in Atlantic City, September, 1941. It was pointed out that the field needed more data on reaction rates and equilibria, as well as equipment cost figures. Teachers were urged to encourage research along these lines.

J. W. Greene (Kansas State) reported that the committee on Safety had been quiescent during the year, but suggested that the time is ripe for coöperation with explosives courses now being offered at many schools.

R. C. Kintner, chairman of the photographic exhibit committee, modestly stated that the exhibit itself would serve as the report of the committee. The exhibit consisted of 211 different photographs from 25 different schools. Thanks was expressed to those who submitted pictures and also to A. H. White for making an exhibition room available.

New Business

J. H. Koffolt (Ohio State) observed that no papers from the Chemical Engineering Division had appeared in the Journal of Engineering Education and suggested that something be done about getting the papers of the division published. L. E. Grinter (Ill. Tech.) reported that one of the other divisions had made arrangements with a publishing house to print the papers in booklet form with some advertising included. The secretary was instructed to investigate the feasibility of such a procedure.

H. S. Gardner (U. of Rochester) made the following suggestions:

A permanent nominating committee be appointed, consisting of the past chairmen of the division, and that the constitution be changed to provide for one vice-chairman instead of two.

Upon motion the executive committee was authorized to make a study of the proposed changes and to make recommendations to the division.

R. C. Kintner (Ill. Tech.) was authorized by the chairman to determine the feasibility of making the photographic exhibit available to various schools in bound form. It was suggested that blue prints of the many new chemical engineering buildings now under construction be brought to the next meeting for display and study.

The nominating committee, C. P. Baker (Northeastern) Chairman, submitted its report. The following were elected for 1941–42:

Chairman, J. C. Whitwell (Princeton)
Vice-Chairman, R. M. Boarts (Tenn.)
Vice-Chairman, W. W. Hodge (W. Va. U.)
Secretary-Treasurer, C. O. Miller

In a special meeting the executive committee voted to recommend to the division that future nominating committees shall consist of the past chairmen of the division present at the meeting.

As chairman of the resolutions committee, C. A. Mann (U. of Minn.) commended A. H. White (President Elect of S. P. E. E.) and the local committee for the efficient manner in which the arrangement of conferences was handled, and for the cordial welcome extended to all visitors, and moved that the Division show its appreciation by a rising vote of thanks.

Mimeographed copies of the papers presented (except at the session on Engineering Defense) may be obtained for $1.00 from C. O. Miller, Case School of Applied Science, Cleveland, Ohio.

CLARK O. MILLER, *Secretary,*
Chemical Engineering Division

COMPREHENSIVE EXAMINATIONS

The work of this Committee centered around two problems of fundamental importance to its work: (1) the development of plans for organizing its work on a permanent basis in order to make possible continuity and integration of effort, and (2) the development and codification of terminology in order to provide a common language for workers in the field. Study of these problems was carried on through the year by various committee members and by others associated with the Committee, and culminated in the conference and luncheon programs at Ann Arbor.

A report on a plan for placing the work of the Committee on a permanent basis was prepared for presentation to the conference by Justus Rising, former Chairman of the Committee. Owing to unexpected inability of Professor Rising to attend the conference, his report was presented and distributed by the Chairman. Discussion of this problem, first at the conference and subsequently at the luncheon resulted in the naming of the chairman with Deans Cloke, Van Leer, and White to go before the Executive Council with alternative plans, the first embodying a request for permanent status as a Division, the second a request for permanent status as a Committee. Each plan provided for a chairman and a secretary having two-year tenure. The Division plan provided for an executive board of nine members (including the chairman and secretary) elected in rotation for three-year tenures. The Committee

plan provided for a rotating membership of nine (including the chairman and secretary) appointed for three-year tenures. Both plans provided for subcommittees for the expansion of the work either territorially or by engineering fields. The plans are in fact quite similar—they differ principally in organizational mechanics. These plans were referred for study to R. A. Seaton's Committee on Relations of Divisions to the Society. In order to provide continuity over the coming year, however, the Executive Committee voted to continue the members of the Committee on Comprehensive Examinations for another year. Some changes may be necessary however, owing to defense activities. The Committee hopes very much however, that by the end of another year one of the plans proposed, or a similar plan, may go into effect.

The Chairman presented a report to the conference on terminology and specifications for comprehensive examinations. This was directed primarily towards nonobjective examinations, and so was supplemented by W. C. White for objective examinations. Dean White had worked with C. V. Mann on the objective terminology, and substituted for Professor Mann who unexpectedly was unable to prepare his scheduled paper. The discussion on terminology surprisingly enough seemed to bring out more points of agreement than of disagreement, but all criticisms and suggestions were recorded in order that they may be utilized as the terminology develops toward final form. At the request of the conference the paper on terminology has been submitted for publication in the JOURNAL in order that it may have wide circulation for study by all interested persons in the Society for the purpose of forwarding criticisms and suggestions for discussion at the next conference. In preparing the paper for publication it has been modified somewhat in accordance with suggestions by Dean White in order to include both objective and nonobjective examinations.

Some important general comments at the conference related to government examinations. Owing to the very large number of candidates involved in Civil Service examinations, the objective type, adaptable to machine scoring, has become very important. In Civil Service examinations and in licensing examinations, the showing of recent graduates of engineering curricula often is surprisingly poor. Probably many such candidates face comprehensive examinations or objective type examinations in engineering subjects for the first time when trying these government examinations. Herein lies some material for reflection over the composition and effectiveness of engineering curricula, especially over the use of comprehensive examinations, and of objective type examinations which differ so markedly from the usual examinations characterized by long problems.

Four of the eight members of the Committee attended the meetings at Ann Arbor; the total attendance eliminating duplications was thirty: twenty at the conference and eighteen at the luncheon. G. S. Timoshenko acted as Secretary at both meetings.

During the coming year the Committee plans to continue its work toward standard terminology, and to proceed with the work of actual experimental formulation and construction of examinations. In doing this, the Committee hopes to gain the coöperation of certain licensing boards, the Civil Service Commission, and certain industrial training courses, in addition to the coöperation of many engineering schools.

H. W. BIBBER — H. M. JENKINS
H. V. CARPENTER — C. V. MANN
R. E. DAVIS — W. C. WHITE
R. H. FRAZIER, *Chairman*

COÖPERATIVE ENGINEERING EDUCATION

The Coöperative Engineering Conference was called to order at 2:00 P.M. on Wednesday, June 5, in Room 243, West Engineering Building, University of Michigan. Ovid W. Eshbach, Northwestern University, presided. The minutes of the previous meeting, held at the University of California, were read.

R. C. Disque, Chairman of the Nominating Committee, made his report. R. L. Langenheim, the choice of the Committee for the position of Chairman of the Coöperative Engineering Division for the year 1941–42, was elected unanimously with instructions to appoint a Secretary. Dean Disque of Drexel Institute moved that the present Secretary turn over the minutes to the new Secretary so that a permanent record might be kept.

Dean Eshbach presented a paper, the subject of which was Contributions of Work Experience to the Study of Scientific and Engineering Subjects.

Following Dean Eshbach's paper a panel discussion was held on the subject of Looking Ahead in Coöperative Education—Opinions on Critical Situations. The participants were Messrs. Fred E. Ayer, University of Akron; Robert C. Disque, Drexel Institute; Ovid W. Eshbach, Northwestern Technological Institute; E. H. Flath, Southern Methodist University; Max Robinson, Fenn College; B. R. Van Leer, North Carolina State College. The most important problem discussed was the possible difficulty in finding employment for coöperative students when the present period of intense activity ends. The difficulty can be lessened, first, by distributing the students thinly; that is, by placing only a very few with each of a large number of coöperating companies; and, second,

by convincing employers of the value of a long training period without regard to economic conditions, and reconciling them to accepting certain difficulties incident to the coöperative method, such as the necessity for a fair amount of "trial and error" in the selection of students and the choice of work experience. Mr. McDaniel emphasized that in general judicious selection of students for admission to coöperative courses followed by the proper care in suiting the student to the job in question provides the most effective security against unemployment. The feeling was expressed that coöperative students should take precedence over young, unmarried men with no educational plans.

The following points were brought out.

In a depression certain schools prefer to leave a coöperative student on a menial job than to have him unemployed. This makes him realize that he is subject to certain unemployment hazards in a free economy.

There is very little danger that a student on a coöperative job will fail to return to college at the appointed time because of any opportunity offered him of continuing as a regular employee beginning at once. While a supervisor or foreman might encourage such a situation, the management, in the case of most large companies, would frown on it.

The fact that many students have relatively high incomes from coöperative jobs was commented on. This is due in general to a large amount of over-time work.

Under present conditions there is a tendency for a few students to leave school because of high wages which can be earned in industry. Their ability to earn these wages is often a result of their experience as coöperative students. This condition causes a slightly greater decrease in enrollment among coöperative than non-coöperative students.

The fact that occupational deferment varies with the locality and policies of local draft boards was discussed. In general, it is expected that upper-classmen in engineering colleges will be given deferment. It was pointed out by Mr. Flath that so far he has had no difficulty in securing deferment even in the case of freshmen.

The likelihood that defense courses and greater opportunities in industry will lead to increased interest in engineering was pointed out.

At the conclusion of the panel discussion, C. J. Freund of the University of Detroit moved that the Chairman appoint a committee to formulate a philosophy of coöperative education to be adopted by the conference and announced to the S. P. E. E. and to other responsible educational bodies.

F. G. SEULBERGER, *Secretary*

ELECTRICAL ENGINEERING

A. L. Albert, Oregon State College, presiding.

The conference was held jointly with Engineering Economy and Industrial Engineering.

Statistical Basis of the Quality Control Program, by S. S. Wilks, Princeton University. Professor Wilks was unable to be present. His paper was presented by E. M. Williams of the Pennsylvania State College. G. Olds presented Mathematical Problems in Quality Control. L. C. Young presented Teaching Quality Control Theory to Engineers.

Donald S. Bridgman, A. T. & T. Co., presented Engineering Training for the Operating Work of Industry. E. D. Ayres, University of Wisconsin presented An Absorbing Adventure in Tackling the Intangibles of Personality. V. P. Hessler, University of Kansas, presented A Statement of Objectives for Electrical Engineering Training.

H. W. Bibber, Chairman, presented the report of the Nominating Committe as follows. The officers were unanimously elected.

For *Chairman,* A. L. Albert.
Vice-Chairman, M. S. Coover.
Secretary, Moreland King.

Willis T. Spivey presented Teaching Problems of the Engineering Defense Training Program. Harold D. Golds presented A Student Counselling Problem, prepared jointly by himself and W. G. Dow.

M. S. Coover, *Secretary*

ENGINEERING DRAWING

The first conference session of the Drawing Division at two o'clock on Monday afternoon, the first day of the convention, was well attended. Two papers and four standing committee reports were presented. Mr. Altz, Chief Draftsman of the Chevrolet Motor Company, gave an excellent discussion of "Drawing in the Defense Industries" which was illustrated with especially prepared wall charts. From the discussion following, it appeared quite evident that the Drawing Standards published by the A. S. A. in 1935 are slowly penetrating the commercial drafting office. Mr. Altz's paper will be published in the *Journal of Engineering Drawing* during the current year.

In order to present both sides of the problem of Engineering Defense Training, Professor Slantz of Lafayette College presented a paper entitled "Training in Drawing for National Security" in

which he emphasized thoroughness of training for the long pull as contrasted with the current short-time programs.

At the luncheon on Tuesday, the regular business meeting of the Division was held. The financial report of the *Journal of Engineering Drawing* proved it to be not only financially solvent but with a wider circulation than in the preceding year. The following officers were elected for the ensuing year:

EXECUTIVE COMMITTEE ENGINEERING DRAWING—1941–1942.
R. P. Hoelscher, Chairman, University of Illinois.
W. H. Seegrist, Secretary, Illinois Institute of Technology.
C. V. Mann, Missouri School of Mines.
G. M. Phelps, Rensselaer Polytechnic Institute.
F. H. Heacock, Princeton University.
N. D. Thomas, Ohio University.
H. C. Spencer, Illinois Institute of Technology.

JOURNAL OF ENGINEERING DRAWING.
R. R. Worsencroft, Editor.
F. M. Porter, Advertising Manager.
F. A. Smutz, Circulation Manager.

EDITOR OF THE T-SQUARE PAGE.
W. E. Street, Texas Technological College.

Following the general theme of the convention, the second conference session was opened with a paper on "Technology in the Industrial Drafting Room" by Mr. Homer C. Baylers of Motch and Merryweather Machinery Company. The expanding interest of the Drawing Division in nomography or graphical methods of computation was well indicated in the paper "Nomography, an Advanced Course in the Graphics Department" and the discussion which followed. This paper was prepared by Professor Douglas P. Adams of M. I. T.

A panel discussion of "Efficient Use of Time in the Classroom and Laboratory" together with standing committee reports completed the afternoon program.

The dinner meeting, always an outstanding affair, was up to the usual standards of previous occasions. With Col. H. W. Miller of the University of Michigan as toastmaster, Professor Avord Fairbanks gave a demonstration-lecture on Modeling in Clay with Professor H. H. Jordan as the model. Needless to say, the audience was both instructed and entertained.

On Wednesday morning, the final conference listened to a panel discussion on Engineering Defense Training Courses in Drawing. The discussion which followed indicated the interest

in the topic and the need for authentic information which was supplied by Dean George W. Case of the Federal Security Agency.

WINNERS IN 1941 NATIONAL DRAWING COMPETITION

Sponsored by the Division of Engineering Drawing and Descriptive Geometry of S. P. E. E., Ann Arbor, Michigan

Classification	Code No.	Instructor	Student	Institution
Class AP				
First Place	271	J. T. Enburg	Albert A. Walla	Univ. of Nebraska
Second Place	151	H. C. Spencer	D. R. Voelkel	Texas A. & M.
Third Place	381	M. Coopey	E. Colby	Oregon St. College
Class AI				
First Place	282	W. J. Judson	Geo. E. Platzer	Univ. of Detroit
Second Place	272	J. T. Enburg	John W. Watson	Univ. of Nebraska
Third Place	402	W. E. Farnham	W. C. Huening, Jr.	Tufts College
Class BS				
First Place	133	G. F. Branigan	Richard Smoll	Kansas State College
Second Place	353	Harold T. Amrine	Daniel A. Meyer	Ohio State Univ.
Third Place	323	F. A. Heacock	R. E. Close	Princeton Univ.
Class CP				
First Place	154	R. O. Loving	R. B. Williams	Texas A. & M.
Second Place	284	J. Gerardi	Edward N. Mroz	Univ. of Detroit
Third Place	384	J. Kovytonvitch	R. F. Mundy	Oregon St. College
Class CI				
First Place	155	J. G. McGuire	B. L. Wade	Texas A. & M.
Second Place	285	J. Gerardi	Paul F. Brinich	Univ. of Detroit
Third Place	355	Harold T. Amrine	Wm. C. Martin	Ohio State Univ.
Class D				
First Place	126	B. C. Kent	John F. Kane	Univ. of Maine
Second Place	356	Jay N. Edmonson	L. J. Breidenbach	Ohio State Univ.
Third Place	276	J. T. Enburg	Emil J. Pelcak	Univ. of Nebraska
Class E				
First Place	277	R. E. Edgecomb	Dale Bell	Univ. of Nebraska
Second Place	187	C. C. Perryman	L. M. Stevenson	Texas Tech. College
Third Place	217	F. Paulsen	John Nohrden	San Mateo Jr. College
Class F				
First Place	38	R. P. Hoelscher	Paul A. Gerding	Univ. of Ill.
Second Place	158	J. G. McGuire	W. F. Tate	Texas A. & M.
Third Place	218	F. Paulsen	Joe Nicoletti	San Mateo Jr. College

COMMENTS OF JUDGING COMMITTEE

1. We recommend that scale be indicated in the specifications to the student for all competition problems involving intersections and developed patterns for facilitating checking.

2. Some drawings were eliminated from judging because of incorrect size or failure to follow specifications.

3. All drawings were judged independently by each of the five judges and the majority decision awarded places.

4. We recommend that no other numbers but institution identification numbers be placed in the title.

5. We recommend the continuance of six members of the judging committee to expedite this work.

JUDGING COMMITTEE:

Leon B. Howe
James E. Robertson
Stephen F. Cleary
Paul C. Hoffman
Ralph S. Paffenbarger, *Chairman*

R. P. HOELSCHER, *Chairman*

The chief activity of the Division will be to conduct the survey of engineering drawing.

R. P. HOELSCHER, *Chairman*

ENGINEERING ECONOMY

I feel that the Committee on Engineering Economy can really be proud of our sessions at Ann Arbor. Because two of our speakers were unable to be present, we combined our Tuesday afternoon program with that of the electrical engineering division. We arranged to follow after the regular electrical engineering division speakers. There were around forty to fifty to start and about twenty stayed with us to the end even though the hour was late. We listened to two of the finest papers we have ever had on our programs, one by Professor Putnam of Case and the other by Professor Miner of Carnegie Institute. At the beginning of the session, Mr. Goetz of our committee gave a synopsis and brief discussion of Mr. Lindemann's scheduled talk. The many fine comments upon these talks bear out my own judgment with respect to them.

Our engineering economy luncheon had Allen Mogensen from New York for speaker and the only regret I have is that he did not give his message to the entire convention assembled—it was very much about his work of work simplification and its relation to engineering economy but it pictured the need for improvement in our defense factories and dwelt with great emphasis upon the human relations involved. It was an excellent speech but unfortunately it was given extemporaneously and probably will not be available for publication.

Paul T. Norton, Jr., of Virginia Polytechnic Institute has consented to take over the editorship of the Engineering Economy Page.

We are making considerable headway with the project described in the enclosed mimeographed page entitled "An Engineering Economy Technical Division." We distributed these sheets at the engineering economy luncheon at Ann Arbor and received an encouraging response. The first thing we must do before going

much further with this matter is to eliminate the word "division" —we have no intention of forming a division in the sense the word is used in the S. P. E. E. It is an effort that I hope can be carried out under the auspices of the S. P. E. E. By next year we should be in a position to present it to the Council. I felt that it should take more concrete form as an effort before any official presentation should be made.

EDMUND D. AYRES,
Chairman, S. P. E. E. Committee on Engineering Economy

ENGLISH

First session of the English conference, Chairman O. J. Ferguson presiding, was held at 2:00 o'clock P.M., June 24, 1941, Rackham Hall, University of Michigan. The entire discussion of the afternoon centered about the paper of R. D. Scott, University of Nebraska, who reported on the results of two years of experimenting with a laboratory method of teaching English to students who enter with inadequate preparation. In the system as set up at Nebraska, the poorer students are not allowed to go directly into freshman English but are required, on their own initiative and responsibility, to take two two-hour periods each week in a writing laboratory, where the student may secure aid from an instructor but otherwise is dependent upon his own resources.

The laboratory course is divided into five parts, beginning with the very simplest rudiments of parts of speech and grammatical relationships. The passing of each part of the course is a prerequisite to all succeeding parts, though the entire course must be covered in one comprehensive examination regardless of grades made on individual parts. The final examination, like the tests on separate parts of the course, is given at the request of the student. Since the course gives no credit, the successful passing of the final examination gives only the privilege of going on into the regular freshman work.

Professor Scott reported that the success of the students doing this laboratory work would seem to justify the system. Most of the students were able to go into the regular freshman English courses, at the end of one semester of laboratory study, and showed greater achievement than did the regular students.

Some antagonism to the non-credit course came at first, said Professor Scott, but later most of the students took a better attitude and seemed appreciative of the opportunity for taking the laboratory course. The cost of the work amounted to about seven dollars per student.

Formal discussions of the paper were presented by C. A. Brown, General Motors Institute, and H. L. Creek, Purdue University. Professor Brown wished that the paper had had more about laboratory work for the regular student; Brown's contention was that if laboratory work is beneficial, its benefits should be extended to all students. He gave his conception of the laboratory method as simply putting the man and the work together, where the non-aggressive student is penalized for his own indolence. Professor Brown also wondered about the use of a control group in the tests, and about the receiving of unauthorized aid by the laboratory students.

Dr. Creek compared the Nebraska experiment with one previously performed at Purdue, in which forty-eight students volunteered to take the laboratory work. They were paired off one by one with regular students with similar entrance grades, and the quality of work compared at the end of the term. With various withdrawals, only fourteen of the original forty-eight actually finished the course, and they showed slightly less improvement than did the regulars. In view of the excessive amount of the work involved, the experiment was considered hardly worthwhile.

At the close of the formal commentaries of Professor Brown and Dr. Creek, the entire group joined in an informal discussion, which brought out that (1) the Nebraska work had been guided by a Master's candidate, sometime a high-school principal; (2) the course was really a correspondence course, given on the campus; (3) after a short preliminary period, the students did a short theme daily; (4) the general review of grammar is retained in the regular classes; (5) engineers are usually above the average in English ability; (6) it is hard to find space in engineering curricula for two two-hour periods in one week; (7) chief value of the course is its development of responsibility; (8) possibility of credit for better students proves an incentive; (9) non-credit courses are necessary because of coddling and poor teaching in high schools; (10) general aims of laboratory course may sometimes be attained by not admitting students to professional courses until one or two years of general college, during which time most of the poorer students will have dropped out of school.

Second session, H. H. Nugent, Rensselaer, presiding, was devoted to the general topic, English and Defense. The first paper was that of Jay R. Gould, Rensselaer, who spoke on Writing and Defense. In his paper, Professor Gould pointed out that in time of military action the need of concise and accurate communication is greater than ever, since oftentimes the speed and effectiveness of manoeuvers are dependent upon clarity of orders. He also pointed out that army life trains for peace time as well as for

war time and that training in good English will carry over into periods of normalcy.

Professor Gould used as an example the newly created committee on civilian defense, whose duties are to (1) give training against subversive propaganda; (2) give reports on activities of groups in patriotic service; (3) use local radio stations for giving out information, instructions, and encouragement. Mr. Gould pointed out that every one of these services is based upon the ability to write and speak good English.

The second paper, Speech and Defense, by W. W. Senseman, University of Michigan, gave emphasis to the importance of speech and speech teachers in the molding of public opinion and the evaluation of rumor, fact, and propaganda. These ends may be accomplished, said Professor Senseman, by giving extension classes to those in need of training in leadership, general speaking, and parliamentary procedure. In the classroom the same purposes may be served by shaping the topics, situations, and attitudes to the needs of a military atmosphere. Mr. Senseman believed that voluntary training in speech does not amount to much, as the routine and discipline of regular classes and assignments are indicated for speech development.

The final paper, Specialized Services, delivered by Theodore Smith, Massachusetts Institute of Technology, dealt principally with the work of the Committee for Aiding the Allies. The opportunities for direct contribution of English training to the armed forces are limited, unless it be in guidance of reading and speaking for officers and enlisted men. Radio programs and report writing do offer some opportunities, especially in those sponsored by the Office of Production Management. English teachers may be of greater service in planning local communications, making inventory of human resources, supporting programs of fact-finding, encouraging and leading of public discussion, and building of confidence in leadership as an aid to preservation of morale.

In the discussion at the close of these papers, opinions and answers to questions indicated that (1) propaganda analysis serves not necessarily to whitewash or to discount propagandic reports but rather to evaluate them; (2) some censorship is necessary in military secrecy and preservation of morale; (3) English departments are not so far threatened with loss of teaching hours because of pressure from degree-giving departments; (4) wars are necessarily won by biased groups, but concentration on any one type or volume of propaganda will defeat its own purpose; (5) old course in "War Aims" in 1917–1918 was largely a failure, because it was given by teachers little schooled in materials of the course; (6) "War Aims" course harmed the teacher more than it did the

student; (7) purpose of the English teacher is to teach writing rather than to give ideas about which to write; (8) English teachers may not be able to explain political or economic theories, but can cite the student to authorities; (9) English teachers are too often trained in some specialized graduate research rather than in the teaching of composition; (10) English teachers should do all possible to counteract the defeatist literature of the past few years.

The final session of the English section was the dinner meeting, June 25, 6:30 P.M., Chairman Ferguson presiding. The chairman made further explanation of the three-week conference of English teachers in technical schools; the seminars of the conference were to begin the following week.

The address of the evening was a paper on English in Engineering in College and After, by H. P. Hammond, Pennsylvania State College. Dean Hammond referred to his own presence and to the presence of many other deans and departmental heads as proof of the interest of administrative officials in the work of English teachers.

Dean Hammond's paper set forth that English training is really the work of a lifetime rather than a part of a college course. He believed that engineering students are superior to other students in general mentality, but that their training is spotted, principally because of poor high-school training. In view of this variant training, Dean Hammond expressed encouragement for the sectioning of students according to ability, but wondered if English teachers are not spending too much time on the poorer students, with a consequent loss to the better material. He believed that for a really satisfactory program of sectioning, English teachers need a more comprehensive test than any so far devised. He called attention especially to the system recently installed at the University of New Hampshire, where credit is not given for English courses until the student is ready to graduate. Thus the administration reserves the right to remand any student to the English department for additional work if his written and oral expression are not kept to proper standards.

Dean Hammond believed that as nearly an ideal arrangement as possible would be two years of required English with an elective in the senior year. Students should be encouraged to map out a plan of outside reading, and the college should provide them adequate reading rooms, with modern books carefully chosen and attractively arranged. Dean Hammond feels that the lifetime habit of self-education is mostly the responsibility of the English department.

In the discussion it was brought out that (1) Dean Hammond contributed to the recent English study of the society; (2) student interest in reading may be stimulated by careful use of magazine articles; (3) high schools have weakened English preparation by discontinuing courses in ancient languages; (4) character and social consciousness may be developed by planned reading; (5) poor readers usually fail courses other than English; (6) some deans, specifically Hammond himself, make a practice of writing high-school principals about the successes and shortcomings of their graduates.

A. M. FOUNTAIN, *Secretary*

EVENING ENGINEERING EDUCATION

The conference was held on the afternoon of Tuesday, June 24, and the three papers listed on the program were presented by the authors. In the discussion that followed, mention was also made of evening undergraduate and graduate instruction at other centers, particularly the recently organized work at Northwestern and Illinois Institute of Technology. A number of angles of the discussion evidenced a great interest in progress made so far.

I feel certain that the entire subject of graduate evening instruction is of vital and growing importance, particularly for institutions in metropolitan areas, and therefore urge strongly that all three papers be published in the JOURNAL OF ENGINEERING EDUCATION.

H. S. ROGERS, *Chairman*

INDUSTRIAL ENGINEERING

The Division of Industrial Engineering sponsored three conferences on technical work, cost control, industrial relations and methods. In addition, a dinner meeting was addressed by John Airey, President of the King-Seely Corporation of Ann Arbor on the topic, the "Task of the Executive in Modern Industry."

The division also participated in a joint session with Electrical Engineering and Engineering Economy where the interesting subject of quality control was discussed. It was suggested that this topic should have a place in the curricula of engineering as a course but sentiment seemed to feel that the topic should be introduced in courses in management only in its introductory phases leaving the more technical and mathematical phases for advanced elective or graduate study.

It also participated in a joint session with engineering economy where Allen Mogensen discussed the effect of work simplification on the economy of manufacturing operations.

The several technical conferences of the division featured talks by leaders in industry. They were especially helpful in pointing out the direction in which the college teaching in those fields might well tend.

At the dinner meeting, the constitution of the division was adopted. Nominations were made for members of the executive committee. The following were elected: L. P. Alford, New York University, H. G. Thuesen, Oklahoma A. & M., R. M. Barnes, Iowa State University, and E. D. Ayres, University of Wisconsin. At a short meeting of those elected, Professor Alford was elected Chairman of the Division, Professor Thuesen, Vice-Chairman, Professor Ayres, Secretary-Treasurer, and Professor Barnes to be Editor. Professors Alford and Thuesen were elected for a two year term while the others were elected for a one year term.

The Division also assisted the general committee in taking care of a discussion period on Engineering Defense Training.

C. E. BULLINGER, *Chairman*

INSTRUCTIONAL METHODS

The opening luncheon of the Committee on Instructional Methods was presided over by William R. Bryans, New York University, Chairman of the Subcommittee on Visual Education, which had been actively engaged during the year in developing a visual education exhibit for the Ann Arbor meeting. Dean Bryans outlined the activities of his Subcommittee and indicated that he and Professor Gus of New York University would be available much of the time during the first three days of the meeting for the purpose of explaining the various items in the visual education exhibit and of discussing their use with interested members of the S. P. E. E. He stated that the exhibit included a collection of slides, film strips, and motion picture films privately produced principally by amateurs for instruction in engineering courses. Programs of the visual aid exhibit listing the material available for inspection and projection and indicating the times at which particular films would be projected were distributed to the twenty-five members present. Among the contributions to the visual education exhibit this year were the following:

Color film and exhibit panel on Motion Study Principles, Ralph Barnes of Iowa State.

Two sound films, U. S. Coast Guard Academy. Supplied by G. R. O'Connor, Commander (E), United States Coast Guard.

50 2 × 2 film slides used in chemical engineering instruction by Tod G. Dixon and G. F. Kinney of Pratt Institute.

Tacoma Bridge Studies (copies of the original, not the news reel) by F. B. Farquharson of the University of Washington.

A set of 47 kodakrome slides on mechanical drawing with electrical transcription. Supplied by E. R. Wilcox of the University of Washington.

The "Triode" an animated film by Clifford Welch, showing electron-flow variations with changes in potential. Supplied by Professor Williamson of Carnegie Tech.

Slides and movies on various subjects supplied by Professor Robert Rice of the University of North Carolina.

Exhibit by the Visual Education Department of the University of Minnesota. Arranged by C. A. Koepke, University of Minnesota.

Roll film mechanics problem material for use in microfilm readers; color movie on basic principles of photoelasticity; animated cartoons on basic principles in machine kinematics; kodakrome slides of etched metallurgical specimens. Baron Shiba air-flow films. Supplied by the College of Engineering, New York University.

Two films "Some effects of fuel injection advance angle on combustion in a high-speed compression-ignition engine." "Slow motion study of normal combustion, pre-ignition, and knock in a spark-ignition engine." Supplied by the N. A. C. A. through G. W. Lewis, Director of Research.

Two films "Goodrich de-icing equipment" and "Streamline visualization." Also 35 mm. roll films on aeronautical subjects. Supplied by William Humphrey, Institute of Aeronautical Sciences.

Stereoscopic projection in color, descriptive geometry problem material and other illustrations, by S. B. Elrod of Purdue and John T. Rule of M. I. T.

Color film on motion analysis by Mr. Ganong of Northeastern University.

The principal speaker at the luncheon meeting was C. A. Koepke of the University of Minnesota who spoke on his experience in visual education. Professor Koepke gave a very stimulating account of the development of visual aids at the University of Minnesota and distributed informative pamphlets issued by the University. He discussed in detail various types of equipment now available and interesting devices that had been developed to improve commercial models. There was a lively discussion following Professor Koepke's address in which most of those present participated.

Report of the Sub-Committee on Visual Education of the Committee on Instructional Methods

William R. Bryans, Chairman

The sub-committee on visual education of the Committee on Instructional Methods came into being in the fall of 1939. Details

of the events which led to its appointment can be obtained by reading the following:

1. A paper by George Tomlinson, senior engineer T. V. A., presented at the conference on Instructional Methods, 1938, Texas Convention. This paper, The Use of Motion Pictures in Engineering Education, is printed in the May 1939 Journal, pages 739 to 744.
2. Part of the 1939 Report of the Committee on Instructional Methods printed on pages 123, 124, and 125 of the October 1939 JOURNAL.

It can be seen that to Mr. Tomlinson belongs the credit of bringing to the attention of the Society the possibilities in motion pictures in engineering education and initiating the resolution at the Penn State meeting which led to the appointment of a sub-committee on visual education.

The work of the committee began last year under the chairmanship of Theodore H. Morgan, Worcester Polytechnic Institute, who prepared and sent out a questionnaire. The purpose of this questionnaire was to determine the opinion of engineering faculties with regard to the Penn State meeting resolutions referred to above, as well as to elicit information regarding the use of motion pictures in engineering colleges generally. The returned questionnaires contain a mine of information both as to those actively interested in visual aids and as to material which has been privately produced solely for educational objectives in engineering.

It has been hoped that all members of the 1940–41 committee would have the opportunity to study these returned questionnaires and consider ways and means of putting into effect some of the suggestions and ideas contained therein. There were two things, however, which made it difficult for this committee to function effectively:

1. Since everything had to be done by correspondence, the composition of the committee was not known until December 1940.
2. The wide geographical distribution of its members naturally made it impossible to have meetings to discuss matters.

Some of our members have felt that we could further the cause of visual education in engineering by an appeal for financial assistance from some of the national engineering societies or foundations. This, and the suggestions in the questionnaires, possibly should have been given some implementation this year but it seemed inexpedient to start any large program in view of the many demands being made on everyone by national defense programs. Per-

haps as defense training programs get less onerous and we get down to a more normal existence our successors may make a start along these lines.

The chairman has carried on considerable correspondence with individuals interested in our objectives and has also arranged for exchange of material between colleges on at least two occasions. The committee hopes that its activities, small as they have been, may have served to maintain interest and have helped to spread a more general knowledge of some possibilities in visual aids to engineering.

Afternoon Conference

Herbert J. Gilkey, Iowa State College, presided at the afternoon conference at which the following three papers were presented:

1. The Comparison of Possible Non-Technical Sequences with the Technical Sequences in the Engineering Curricula. W. Otto Birk, University of Colorado.
2. Evaluation of Results from Different Types of Educational Processes. F. C. Dana, Iowa State College.
3. Preliminary Results from Experiments in Teaching Mechanics. J. O. Draffin and F. B. Seely, University of Illinois.

Each of these papers was excellently prepared and effectively presented, the speakers having arranged to divide the time available approximately equally. As a result there was adequate time for an interested discussion of the issues raised. The conference was attended by twenty-six persons representing twenty-two different institutions from all over the country.

Dinner Meeting

At the dinner sponsored by the Committee, Theodore H. Morgan presided. He introduced Carl S. Ell, President of Northeastern University and Chairman of the Committee on Instructional Methods, who spoke briefly about the work of the Committee and its able personnel. The address of the evening on Defense Training—an Emergency and an Opportunity was given by William E. Wickenden, President, Case School of Applied Science. Always a fascinating speaker, Dr. Wickenden gave an extremely absorbing presentation of the enormity of the problem with which the nation is faced at the present time. He pointed out that it is relatively easy to propose huge developments in the interest of national defense, but that it is quite another problem to translate such commitments into effective action. Dr. Wickenden enumerated some of the specific issues that would need to be met as the country goes

forward on the defense program and indicated the ways in which engineering schools could be most helpful.

Comments on the address were made by Charles F. Scott and there was considerable informal discussion among those present after the meeting had formally adjourned.

CARL S. ELL, *Chairman*

JUNIOR COLLEGES

The Committee consisted of the following persons: E. R. Hedrick, University of California at Los Angeles; H. H. Wheaton, Fresno Junior College, California; R. A. White, Grand Rapids Junior College, Grand Rapids, Michigan; J. A. Strelzoff, LaPlume Junior College, LaPlume, Pennsylvania; E. C. Douglas, Joliet Junior College, Joliet, Illinois; C. A. Anderson, University of Pittsburgh, Johnstown, Pennsylvania.

No special activity or project was taken up during the year. Every member was contacted by one or more letters but no committee meetings were held.

The program for this meeting consisted of a luncheon meeting, held Wednesday noon, and a conference, held Wednesday afternoon. E. C. Douglas presided at both of these meetings. George I. Altenburg, Highland Park Junior College, addressed the luncheon meeting on The Present Status of Terminal Engineering Courses in Junior Colleges. L. L. Jarvie, Rochester Athenaeum and Mechanics Institute, addressed the conference meeting on The Development of a Terminal Curriculum of Technical Courses for Junior Colleges.

On May 28, the Committee had a communication from Walter C. Eells, Executive Secretary of the American Association of Junior Colleges, requesting that the S. P. E. E. Committee on Junior Colleges accept the responsibility of writing-up one or more monographs pertaining to engineering and technological material of a semiprofessional nature. Mr. Eells request was as follows:

> My request, therefore, is that your group at Ann Arbor discuss the possibilities in this line and if it appeals to you favorably that you appoint a committee or committees to work with me in the next year or two. It seems to me probable that more than one monograph would be desirable in the whole field of engineering and technology even with a limitation to the semi-professional levels. I hope you will consider how many such are desirable to cover the different junior college technological fields adequately. Aviation suggests itself to me as one such field. Mechanical fields, radio, oil technology, etc., are others. Or perhaps you will work out a better division of the entire field if you give the matter consideration.

If the idea appeals to your group I would be glad if they would appoint a working committee for each desirable monograph. I would think these committees should be composed in part of junior college instructors but not necessarily limited to them.

The following report comes from the chairman of the conference meeting, Earl C. Douglas: The proposal of Dr. Eells was submitted to the group at the luncheon meeting. A motion was regularly passed that the Committee should coöperate with Dr. Eells in writing-up the monograph or monographs pertaining to engineering and technological work of a semi-professional nature. In the discussion of this motion it was suggested that any committee working on this material should have members from the Technical Institute Division of the S. P. E. E. or at least the cooperation of this section.

Dr. Eells, in his earlier communication, sent to the Committee a general outline which he suggested should be followed in making-up the engineering and technological monographs. This material is being held by the Committee Chairman and will be turned over to whoever may be made responsible for carrying out this action.

C. A. ANDERSON, *Chairman*

LABOR RELATIONS

At the annual meeting the Committee sponsored four events. They joined the Mechanical Engineering group at dinner on Tuesday evening, June 24th, and furnished the speaker, Fred Rising, Manager of the Automobile Parts Manufacturers Association of Detroit. Mr. Rising gave a very interesting description of negotiations between employers and labor and outlined the fundamental reasons for labor unrest. The Wednesday noon luncheon was devoted to a round table discussion without any formal program.

At the Wednesday afternoon conference R. G. Waldron, Personnel Director of the Hudson Motor Car Company, discussed Industrial Relations in Defense Work and J. W. Riegal, University of Michigan, presented Coöperation Between College and Company in Industrial Relations. While there were only fourteen present the discussion was very animated and the conference lasted from two o'clock until 5:15. Dr. Riegal presented a carefully prepared paper that merits publication in the JOURNAL.

On Friday morning T. W. Prior, Goodyear Tire Company, discussed the Responsibility of the Engineering College for the Present Chaos in Industrial Relations.

At the present time labor relations are causing a definite bottleneck in production. This fact and some of the remedies were forcibly brought out in the several papers and discussions.

T. C. Adams R. S. Hawley
R. W. Crain F. A. Magoun
L. M. Gilbreth D. B. Porter
G. L. Sullivan, *Chairman*

MATHEMATICS

There were three sessions of the conference of the Mathematics Division, the first one being a joint session with the Division of Chemical Engineering. All sessions were well attended. At the joint session six papers were presented, three by chemical engineers and three by mathematicians. The secretary of the Chemical Engineering Division will report on the papers given by the chemical engineers. A digest of the other three papers is as follows.

The first paper, given by Gerald E. Moore, University of Illinois, was a discussion of the organization and content of a course in mathematics at the University of Illinois in coöperation with the department of chemistry. Students from physics, chemistry, chemical engineering, ceramic engineering and mining engineering took the course. It aims to give training in first year college mathematics, eliminate unnecessary topics, unify the course and use applied problems whenever possible to illustrate the mathematical theory. To date the results seem to be satisfactory.

The second paper was given by C. C. Torrance, Case School of Applied Science. It treated the following three topics. (1) A definition of entropy which is independent of the path from one state to another for any real substance. On a basis of this definition computations can be made without knowledge of the specific formulas for the internal energy and pressure as functions of volume and temperature. The treatment is both brief and simple. (2) A discussion of fluid flow which shows that if the density if a fluid is retained (contrary to custom) in the integrals representing the velocity potential and strain function, that the integrals involved represent respectively the totalized tangential and normal momentum along any given path in the stream of flow. (3) Some remarks on the uses of complex variables from the standpoint of vector analysis.

The third paper was presented by R. V. Churchill, University of Michigan. This paper pointed out the fact that in quite general problems in heat conduction a simple set of transformations of the variables in the differential equation and boundary condi-

tions can be used to show the relationship between the temperatures at corresponding points of any two geometrically similar solids of the same material, subjected to similar initial and surface temperature conditions. (*Physics*, Vol. 6 (1935) pp. 100–104.) The discussion pointed out the fact that the method applies to the fusion of spheres. It shows, for instance, that the time required to melt a solid sphere by keeping its surface temperature fixed is proportional to the square of the radius. The absence of convection is assumed. The method is simple and conclusive. It can also be applied to problems in vibration and to other problems that can be written as boundary value problems.

At the other sessions of the conference seven papers were presented. Only six will be reported here as the chairman's address by R. S. Burington of the Case School of Applied Science will appear in the journal.

The paper by E. D. Rainville gave a description of some of the common problems met in predicting temperatures in concrete dams. Solutions of some of these problems were exhibited, and some unsolved problems mentioned. Comparisons were made between computed and observed values of the temperature, and it was pointed out that there is ample justification for the assumption that the mathematical problems closely approximate the physical situation.

The paper by James G. Baker on Geometrical Optics pointed out the fact that the characteristic function as first used by Hamilton gives an elegant and powerful method for ascertaining the performance of optical systems. The characteristic function is first taken as the total optical path between two points. Its first variation leads to the identification of the path actually followed by the light. With regard to the important branch of geometrical optics dealing with rotationally symmetrical optical systems, the characteristic function can be so redefined that its first variations lead directly to the errors in the images yielded by the lens system. For these systems the characteristic function is a function of three rotational variables and the color of light. Its expansion in Taylor's series leads to image errors of the first, third, fifth and higher orders of aberration. In modern instruments of large aperture and field, even the fifth order terms are insufficient to describe the behavior of the instrument. Nine aberrations of the fifth, fourteen of the seventh and correspondingly greater aberrations of the higher terms are incapable of total removal in any camera system obeying Maxwell's requirements. The lens designer is forced to balance these aberrations as well as possible by means of small changes in the radii of curvature of the surfaces, separations and indices of refraction.

The paper of Paul Nemenyi of Chicago was a presentation of an outline of a course in general fluid dynamics presented from the mathematical point of view.

A history of the development of the differential analyzer, some statements as to its construction and its uses in obtaining particular solutions for differential equations was given by S. H. Caldwell of the Massachusetts Institute of Technology. He stated that the differential equations came from the fields of atomic physics, cosmic rays, acoustics, aeronautics, mechanics, chemistry, chemical engineering, geophysics, seismology, astronomy, meteorology, statistics, and sanitary engineering. The great power of the machine lies in the fact that it is a quantity production machine.

The amount of mathematics given to five different groups of Naval Officers at the Naval Postgraduate School was outlined by R. E. Root of the U. S. Naval Academy. These officers are graduates of the Naval Academy with about six or seven years of service as commissioned officers. All groups take a general review of their undergraduate mathematics, ordinary and partial differential equations and vector analysis. Certain of the groups take courses in statistical methods, nomograms, dynamics and other topics in addition.

W. C. Brenke reported on the high school preparation for the study of engineering mathematics, and made some suggestions relative to the training and guidance of prospective engineering students.

J. H. WEAVER, *Secretary*

MECHANICS

The program of the Mechanics Division Conference comprised a morning and afternoon session with presentation of papers, as well as a luncheon meeting and the annual dinner. All of these events took place on Monday, June 23, 1941. The attendance at all of the sessions was unusually good. There were approximately forty at the morning session, fifty at the luncheon, twenty-five at the afternoon session, and sixty at the annual dinner.

The morning session was devoted to the presentation of three papers: Minimum Acceptable Achievement in Mechanics by Glen N. Cox, Louisiana State University, Achievement Tests in Mechanics by Warren E. Wilson, Colorado School of Mines, and Mechanics and the Junior Engineer Examination by P. A. Willis, Examiner, U. S. Civil Service Commission.

Professor Cox's paper presented the background of previous studies of the subject by various committees of the S. P. E. E. In particular he devoted some time to the data he was able to gather

concerning the Mechanics School which was held in Madison, Wisconsin, during the summer of 1937. It appears that the complete report of this enterprise, which was published by the Society in Bulletin No. 14, is no longer in print. As a result, Professor Cox sought and obtained a considerable amount of information from individuals who were present at that school. The value of his work is attested by the fact that the discussion of his paper was extended and spirited. Several of those in the audience had been present at the school and their recollections of the conclusions reached there were not always identical. After presentation of this extremely valuable background material, Professor Cox went on to evaluate it in terms of present day needs. In closing he led up to the necessity of determining some means by which minimum achievement might be tested. An approach to the solution of this problem was given in the next paper by Warren E. Wilson on achievement tests.

Professor Wilson gave the results of his studies on the preparation and use of achievement tests in Mechanics. He has interested himself for some time in the subject, and while he admitted that his results were not conclusive, they were indicative of the fact that the achievement test, when properly constructed, may serve to give a more objective rating of students than can be obtained by other types of examinations. He was careful to state that in the light of present knowledge, the achievement test should not be used exclusively but should be employed in conjunction with other types of tests to give added evidence of the student's mastery of the subject. Professor Wilson's paper also evoked considerable discussion. In fact it became necessary for the chairman to request that further discussion be delayed so that there would be time to hear Mr. Willis' paper before the end of the morning meeting.

Mr. Willis' paper was correlated to a remarkable degree with those presented by the preceding speakers. He spoke of the procedures used by the Civil Service Commission in setting up examinations for the rating of junior engineers. He pointed out that such examinations were not being given at present because of the urgency of defense needs, but stated definitely that the Commission was of the opinion that it was unfortunate that it had become necessary to omit the examination technique of normal times. Mr. Willis stated that the Commission rated from seven to ten thousand examination papers for junior engineers in each calendar year. Therefore, some years ago a policy was adopted of using an objective type of achievement test. Mr. Willis indicated the nature of questions which had appeared on junior engineering examinations in Mechanics but was of course unable to give specific details inasmuch as such information is confidential and restricted. In

connection with the two previous papers, Mr. Willis expressed the thought that their approach was closely consistent with that adopted by the Civil Service Commission. He indicated that the Commission and he himself were very much interested in attention being given the subject by the Mechanics Division of the S. P. E .E. and that he would be pleased to coöperate in every possible way in carrying on the study. The discussion of Mr. Willis' paper was brief, not because of lack of interest but because the time for luncheon had already been passed.

During the luncheon informal discussion continued on the general subject of the three morning papers. The general reaction of those attending the meeting was that it had been an unusually stimulating and profitable one and the hope was expressed that further investigation might be undertaken.

At the afternoon session two papers were presented: Mechanics After Graduation by M. V. Barton of Cornell University and Mechanics Grades and Grading by R. V. James, University of Oklahoma. As the titles indicate, both papers pertained directly to the general theme of the morning meeting.

Professor Barton's paper gave the results of his experience in teaching extramural courses in mechanics of aircraft structures to employees of the Bell and Curtiss-Wright Airplane Companies at Buffalo, New York. His students came from fifty different engineering colleges and had been out of college for approximately five years. He stated that he had found that the greatest need of these men was a thorough review of fundamental principles. He reported that many of them sought formulas and design procedures which could be directly applied to their work. When such procedures were given them, they were often used blindly without full comprehension of the limitations or of the fundamental theory upon which they were based. Professor Barton pointed out that although it was difficult to interest the students in perfecting their basic knowledge before seeking to solve problems of application, the students nevertheless showed considerable growth in intellectual power when this was done.

Professor James's paper, Mechanics Grades and Grading, was a compilation of the results of a questionnaire sent out by him to a number of representative engineering colleges. He reported that there seemed to be general concern as to the accuracy of conventional essay and problem quizzes and examinations. His data disclosed that the usual type of hour quiz comprised three problems. Many of those who answered his questionnaire indicated dissatisfaction with this type of quiz in that it was obviously impossible to cover the entire range of the subject upon which the quiz was based. It was stated that the necessity for varying quizzes from year to

year has the result of putting the emphasis one year on one topic and that of the succeeding year on a different one. Professor James also reported a variation in grades between institutions as well as from year to year in the same institution even though the numbers concerned were sufficiently large to be statistically valid. His conclusion was that a more objective means of establishing students' grades should be employed. There was considerable discussion of both of the papers in the afternoon session.

The annual dinner was a thoroughly delightful affair and had the largest attendance of any previous similar function within the memory of the chairman. The speaker of the evening, Professor J. N. Goodier, addressed the group on the intriguing subject, Anything May Happen. His remarks concerned themselves with his personal experiences as a consulting engineer. Professor Goodier has a rare gift for combining entertaining humor with technical insight, and I am confident that all those present were stimulated by what he had to say.

Because of the enthusiastic interest shown by the members of the Division in the subject of achievement tests, the executive committee present at the meeting agreed unanimously to direct the chairman to make a request of the Council of the Society for funds to undertake further study of the subject. It was proposed that such studies be carried on at not less than eight representative engineering colleges, and that if funds were made available by the Society, they would be used to cover the cost of material, postage, and clerical help. Such request was prepared by the chairman and submitted to Secretary Bishop for consideration of the Council.

During the annual dinner two new members of the executive committee were elected for a term of four years to fill the vacancies occurring as a result of the completion of the terms of W. B. Johns, Georgia Institute of Technology, and C. T. Olmstead, University of Michigan. A closed ballot was taken as a result of which the following were elected: F. L. Everett, University of Michigan, and Jasper O. Draffin, University of Illinois.

ARTHUR S. ADAMS, *Chairman*

ON DEVELOPMENT AND PLACEMENT

The Committee desires to confine its report to certain reflections which result from the work of the Committee during the year. The Committee has not been in a position to submit the results of any extended study or investigation.

Warning to Recent Engineering Graduates

It is obvious to all concerned that important changes have taken place in recent years in the range of opportunity presented to graduates and recent graduates of engineering colleges. In former years positions were at a premium and a certain proportion of each graduating class was confronted by a serious employment problem. During the past year industrial activity has developed so rapidly that almost any college graduate in engineering can choose from a number of openings.

The result is that the earnings of young engineers have risen sharply and it appears desirable that young engineers be warned that these conditions will not continue indefinitely. Very much of the present industrial activity is based upon military and naval requirements and will be curtailed or eliminated the moment these requirements need no longer be met.

It is doubtless impossible to suggest any definite procedure to the young engineers in order to save them from the impact of the restriction of industrial activity when it comes. However, we can at least warn them of the shock and we can suggest that they

(*a*) Take every possible advantage of the abundance which now prevails, and conserve as much of their earnings as possible against the future.

(*b*) Induce in themselves a frame of mind which will enable them to accept a much less favorable state of affairs when and if this should be necessary.

Young Engineers to Invest in Themselves

Because of the uncertainty of the times, there is a general lack of faith in the stability of all kinds of physical and material values. Real estate, insurance, savings accounts, investments in stocks and bonds, all these may depreciate to nothing, taxes may be heavily increased and personal resources may be confiscated before the present world disturbances are eliminated.

In view of these uncertainties, young men should be directed to invest as much as possible of their earnings and their time in a value which cannot be lost while they live and retain their health, and that is their personal development, the perfection of their abilities and powers.

One cannot imagine any social condition in which a man will not be better off as a result of the development of his powers. And it is easy to imagine a set of circumstances in which a capable, resourceful and cultivated individual will have a great advantage

over another who has, or had, property and possessions of a material character.

This does not mean that young engineers should not be insured, should purchase no property, etc. They should continue to do all that is normal and reasonable. However, they should devote more time and resources than they had probably intended to personal development by formal advanced studies, reading, evening schools, engineering societies, technical and professional, as well as general and cultural efforts of all kinds.

Warning to Educators

The Committee agrees that it is not out of place to warn engineering educators not to neglect the primary purpose of their faculties and facilities, the education and development of the conventional type of professional engineers.

Because of the great demand upon the engineering schools at the present time for short and intensive courses of all kinds, not merely E. D. T. courses, to train specialists quickly for some urgent industrial or government need, there is an inevitable danger that educators will concentrate so much upon these new and more or less fascinating efforts, that their normal and primary work may receive less thought and attention than it should.

Viewpoint Concerning Placement and Development

The Committee proposes that there be included in the program for next year a discussion of the philosophy of the overall procedure of placement and development. During the last 20 years there has been important development in the colleges and in the industries of all those activities whereby young men are prepared for industry, interviewed, engaged, and trained for their work in industry by means of apprenticeships and special training courses. It has been generally assumed that all these activities are beneficial. However, a viewpoint has arisen in the past few years which holds that these activities can be much overdone and that the young man who passes through a carefully organized program of this kind is much less self reliant and resourceful at the end of several years than he would be if he were merely sent out from the colleges and left to shift for himself, solving his own adjustment problems in industry as best he can. Those who hold this opinion believe that the carefully directed and supervised young engineer becomes so dependent that he cannot make his own way in the world.

The Committee proposes that this question might well be con-

sidered by means of a presentation of both viewpoints or possibly an organized debate.

M. M. BORING N. C. EBAUGH
J. R. BANGS S. B. MORRIS
W. J. HEBARD B. K. SWARTZ
C. J. FREUND, *Chairman*

PHYSICS

Three conferences were held on Physics, comprising a panel discussion and an informal luncheon discussion on The Function of Physics Courses in the Engineering Curricula, and an illustrated lecture on The Industrial Applications of the Spectrograph, followed by an inspection of the Physics Laboratories of the University of Michigan.

In the panel discussion points of view on how physics departments can be of maximum service in the program of engineering education were presented by representatives for the various engineering curricula as follows: A. S. Langsdorf, Washington University, for Electrical Engineering, R. C. Ernst, University of Louisville, for Chemical Engineering, E. A. Holbrook, University of Pittsburgh, for Mining and Metallurgical Engineering, H. B. Dirks, Michigan State College, for Mechanical Engineering, and L. E. Grinter, Illinois Institute of Technology for Civil Engineering. Dr. Grinter was assisted in his part of the program by J. S. Thompson, Department of Physics of the Institute, with whom he engaged in a series of questions and answers. The position of the physics departments was presented in the panel discussion by E. P. Slack, Polytechnic Institute of Brooklyn.

The foregoing program provoked a lively and prolonged discussion on the part of engineers and physicists in attendance at the conference. Throughout the program the engineers stressed the desirability that physics departments emphasize fundamental concepts, definitions and principles, minimizing applications such as, for example, A.C. and D.C. machinery. The attitude was expressed that students should be disciplined in working from fundamentals. Stimulating discussion arose on the pedagogically optimum sequence for presentation of fundamentals, especially in mechanics, and on correct formulations in thermodynamics.

There was some lack of agreement on the importance of modern physics in the basic course in physics for engineers.

Emphasis was laid on the important role which measurement plays in the subject of physics. A great deal of discussion was devoted to the laboratory program, there being some advocacy to increase the amount of laboratory instruction. Wide divergencies

were revealed in the discussion regarding the practices and approaches of various physics departments, especially with reference to laboratory exercises and laboratory reports. Although some physics departments require practically no written descriptions, explanations or discussions in laboratory reports, instruction in report writing was especially referred to by several of the engineering speakers as an important phase of physics instruction.

Some discussion was held on the proper location of physics courses in the engineering curricula. One suggestion was that physics be made a senior course, a sort of climax to the engineering curriculum. The program, now in effect in a number of institutions, of offering an elementary introductory freshman course in physics followed by a more exacting sophomore course, met with rather general favor.

It was agreed to be common experience that the students always find greatest difficulty at the beginning of the physics course. Experiments were cited where the course was begun with subjects other than the traditional mechanics. The greatest difficulty, as usual, was encountered early in the course.

The observation was made that the customary 10 or 11 semester hours for physics is rather inadequate, especially when it is necessary to contend with the frictional drag of students who are eventually to be eliminated from the engineering course.

The luncheon discussion was led by O. S. Duffendack, University of Michigan. The idea was stressed that engineering is applied physics and that engineers are drawing from increasingly wider realms in the subject matter of that science, as witnessed by the title, "spectroscopic engineer," now used in several plants.

The need for closer coöperation between physics and engineering teachers in the adoption of units was brought out. Discussion revealed a wide diversity among physics departments in the emphasis given the various systems of units in the several branches of physics. Several engineers spoke in favor of the teaching of M.K.S. instead of c.g.s. units in the physics courses, and expression of opposition, although invited, was not forthcoming. The suggestion met with favor, that a study of units be made during the coming year, with a view to the reaching of some agreement between engineers and physicists and the adoption of some position by the Society on questions of units. The officers of the Society and the Committee on Physics for the coming year may care to act on this suggestion.

Following the luncheon, the conference assembled in a physics lecture room for a vivid presentation of the extensive, yet streamlined, spectrographic techniques now regularly employed in the steel industry. The paper was given by H. B. Vincent, University

of Michigan, in the absence of R. P. Sawyer, who was called to active service with the U. S. Navy after the program was printed. At the conclusion of the paper the spectrographic laboratories, electron microscope, cyclotron, and ruling engine were visited under the guidance of E. F. Barker, Chairman, Department of Physics of the University of Michigan.

JAMES G. POTTER, *Chairman*

TECHNICAL INSTITUTES

At a meeting on June 24 of the representatives of the four technical institutes present at the annual meeting, a motion was passed to continue John T. Faig as Chairman of the Executive Committee. He was authorized to write to the various technical institutes that have shown interest, that are non-profit organizations and that come within W. E. Wickenden's definition of a technical institute, asking that each appoint a representative for the executive committee.

JOHN T. FAIG, *Chairman*

THE T-SQUARE PAGE

DEVOTED TO THE INTERESTS OF THE
DIVISION OF ENGINEERING DRAWING

WILLIAM E. STREET, *Editor*,
Agricultural and Mechanical College of Texas

Executive Committee Engineering Drawing 1941–1942:
R. P. Hoelscher, Chairman, University of Illinois.
W. H. Seegrist, Secretary, Illinois Institute of Technology.
C. V. Mann, Missouri School of Mines.
G. M. Phelps, Rensselaer Polytechnic Institute.
F. H. Heacock, Princeton University.
N. D. Thomas, Ohio University.
H. C. Spencer, Illinois Institute of Technology.

Journal of Engineering Drawing:
R. R. Worsencroft, Editor. F. M. Porter, Advertising Manager.
F. M. Smutz, Circulation Manager.

Editor of T-Square Page: W. E. Street, Agricultural and Mechanical College of Texas.

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Proficiency Tests: A. Jorgensen, Chairman, C. V. Mann, C. L. Svensen, C. L. Brattin, S. B. Elrod.
Bibliography: H. H. Fenwick, Chairman, F. M. Warner, E. F. Tozer.
E. D. T. Courses in Drawing: J. Gerardi, Chairman, W. H. Seegrist, W. B. Johns.

NEW MEMBERS

ACKERMAN, ADOLPH J., Director of Engineering, Dravo Corporation, Neville Island, Pittsburgh, Pa. F. L. Bishop, Nell McKenry.

APPLEGATE, C. E., Educational Sales Dept., Leeds & Northrup Co., 4901 Stenton Ave., Philadelphia, Pa. John A. Goff, F. L. Bishop.

BAUER, GEORGE C., Chief Draftsman, Curtiss Wright Technical Institute, Glendale, Calif. F. M. Warner, Alfred Jensen.

BENSON, ARNOLD, Chairman, Electrical Engineering Dept., University of Denver, Denver, Colo. A. Naeter, C. L. Nickalls.

CLAYTON, WALTER C., Chief Engineer, Curtiss Wright Technical Institute, Glendale, Calif. F. M. Warner, Alfred Jensen.

FORSTALL, WALTON, Instructor in Mechanical Engineering, Lehigh University, Bethlehem, Pa. F. V. Larkin, T. T. Holme.

GOODALE, STEPHEN L., Professor of Metallurgical Engineering, University of Pittsburgh, Pittsburgh, Pa. Re-admission.

MILLER, JOSEPH H., Associate Commissioner in charge of higher and professional education, State Education Dept., Albany, N. Y. F. L. Bishop, Nell McKenry.

O'FARRELL, JOHN B., Technology Librarian, College of the City of New York, New York City. G. J. Bischof, H. T. Updegrove.

PAINTER, ROBERT J., Assistant to the Secretary, American Society for Testing Materials, 260 S. Broad St., Philadelphia, Pa. O. W. Eshbach, H. J. Gilkey, L. W. Clark.

RYAN, DAVID G., Associate Professor of Mechanical Engineering, University of Illinois, Urbana, Ill. Re-admission.

SAWYER, RALPH A., Assistant Professor of Engineering Drafting, University of Maine, Orono, Maine. W. S. Evans, Paul Cloke.

VAN WERT, LELAND R., Chief, Metallurgical Div., Leeds & Northrup Co., 4901 Stenton Ave., Philadelphia, Pa. G. W. Case, J. A. Goff.

VILLEMONTE, JAMES R., Instructor in Civil Engineering, The Pennsylvania State College, State College, Pa. G. A. Rohlich, F. T. Mavis.

WILSON, CURTIS L., Dean, Missouri School of Mines and Metallurgy, Rolla, Mo. E. W. Carlton, J. B. Butler.

COLLEGE NOTES

In 1939–40 the total enrollment at **Case School of Applied Science** was 1609, that is, before the present national emergency. This fall we have the largest enrollment in the history of the college (1880–1941). There are 998 undergraduate students, 800 others in the Evening Division, 146 taking post graduate work. In addition there are 1500 enrolled in the Engineering Science and Management Defense Training courses. In our present training program there are 3444 students, but the number of duplicates is not yet known. It is safe to say, however, that our present total enrollment is twice that of the fall of 1939.

Extension courses are being taught by Case faculty members in Ashtabula, Lorain, Elyria, Canton, Ravenna and Youngstown. Case trained approximately as many (1500) last spring and summer.

The growth of our freshman class indicates the present trend. In 1939, 290; in 1941, 328. Upper classes are maintaining their usual level and the sophomore class this year shows a gain of 40 men over last year. Many of these have transferred to Case from liberal arts colleges.

In answer to a question (How is the draft affecting enrollments and courses for men, and has there been any shortening or streamlining of courses as a result of the National Emergency) our answer is No. Most of our students have been given deferred rating since they are specializing in engineering subjects of great value to national defense. Also, there has been no shortening or streamlining of courses. All men must retain the high scholarship requirements of the college and must complete four full years of study.

The answer is yes to the question (Is the current emergency need for especially trained people changing the division of opinion on whether young people should have classical or practical education, or a mixture?). Moreover, Case is striving to give her students as much of the liberal or classical as possible within the framework of an engineering education. All students must take 30 credit hours of work in non-technical courses including English, History, and Economics. Dr. W. E. Wickenden, president, has said: "The college is not content merely to train men as technicians, but to educate them in the problems of life as well." This

suggests a new emphasis on liberal rather than too highly specialized engineering training in the technical schools.

H. R. YOUNG,
Faculty Manager of The Case News Service

University of Maryland announces the following faculty appointments for the academic year 1941–42:

George F. Corcoran, formerly at State University of Iowa, Chairman, Department of Electrical Engineering.

Arthur C. Kurzweil, Stanford University, Assistant Professor of Civil Engineering.

M. V. Barton, formerly at Cornell University, Assistant Professor of Mechanical Engineering.

Charles A. Shreeve, Jr., formerly at Pratt Institute, Assistant Professor of Mechanical Engineering.

Gomer L. Davies, Case School of Applied Science, Lecturer on Electrical Communications.

C. A. Hogentogler, Jr., formerly at George Washington University, Instructor in Civil Engineering.

Carl W. Gohr, Michigan State College, Instructor in Civil Engineering.

Robert W. Dayton, University of Wisconsin, Instructor in Engineering Drawing.

Myrl H. Bolds, formerly at Purdue University, Instructor in Engineering Drawing.

Michigan College of Mining and Technology.—Enrollment as of October 1, 1941, at the end of three days of regular fall-term instruction, was 766 as against 832 at the corresponding time in 1940. Enrollment as of January 20, 1941, was 883, and it is anticipated that the corresponding figure in January, 1942, will be between 800 and 810. In addition, a number of students are taking national defense training courses at the college.

Men added to the staff are Associate Professor Chester Russell, electrical engineering; Assistant Professor J. M. Crockin and M. W. Bredekamp in the department of chemistry and chemical engineering; Robert B. Oliver as instructor in metallurgical engineering; and A. B. Epple, R. R. Hagen, and Edward Niemi as instructors in mechanical engineering. Nearly all these men are replacing faculty members who are in the military or naval service. Men of professorial and instructorial rank now total eighty-five.

Promotions are: V. L. Ayres from assistant to associate professor of geological engineering; and B. B. Bennett (English), Edward Cahoon (mineral dressing), Raymond Marcotte (metal-

lurgical engineering), and V. O. York (electrical engineering) from instructors to assistant professors.

Recent and projected expansion of the physical plant includes the enlargement, through federal funds, of the drill field used by the college R. O T. C. engineering regiment of approximately 400 men. This work is nearing completion. The college's expansion also entails the expenditure of $100,000 for increasing the physical space and facilities of the chemical engineering department.

Curricular changes are few. The most important is the addition of a second year of required German to the curriculum in Chemistry.

Missouri School of Mines and Metallurgy.—Curtis L. Wilson has succeeded Wm. R. Chedsey as Dean of the Missouri School of Mines and Metallurgy. Dean Wilson comes here from the Montana School of Mines, where, for a number of years, he was professor of metallurgy. Dean Wilson graduated from the Montana School of Mines and later studied in Germany, receiving his degree of Doctor of Philosophy from the University of Goettingen.

Stanley A. Trengove has succeeded C. R. Forbes as professor of mining who is on leave. Dr. Trengove received his Doctor's degree in Economic Geology from the University of Minnesota and has had experience at that school. He later acted as manager of one of the Oliver Iron Mining Company's properties. Wm. C. Alsmeyer, replaces Vernon A. C. Gevecker in the Civil Engineering Department. Other additions include: Nicholas Costakos, Mechanics Department; J. W. Dunn, Petroleum Engineering Department; Leonard Stearns, Ceramics Department; A. D. Topping, Mechanics Department; R. W. Weber, English Department; W. W. Gandy, Mathematics Department; and M. D. Livingood, Instructor, Chemical Engineering Department.

The School of Mines occupied on September 1 the new Chemical Engineering Building provided for by the State Legislature two years ago. Due to failure to release funds, only one-half of the building has been completed. This will house the courses in chemical engineering, organic chemistry and a part of the freshman chemistry work.

The State Legislature has, during the past session, provided an appropriation of $250,000.00 for the construction of a new power plant at the Missouri School of Mines and Metallurgy.

The enrollment at the Missouri School of Mines this year was down seven per cent over last year, the principal loss being in the freshman class.

Norwich University has opened its doors for the beginning of the 123rd academic year with the largest enrollment in history. Well over 500 men have registered, 165 of these being Freshmen.

Two buildings constructed this summer, a new mess hall and an engineering laboratory building, are now ready for use. New mechanical engineering equipment, made possible through a legislative appropriation, will be housed in the building formerly used as a mess hall. The new White Mess Hall is generally considered one of the most beautiful buildings on the entire campus.

In order to take care of the increased size of the school new members have been added to the faculty: Howard Duchacek, instructor in mechanical engineering, 1939 graduate, Worcester Polytechnic Institute; Lewis L. Glow, instructor in chemistry, 1939 graduate, Massachusetts State, master's degree, 1941; William W. Hammerschmidt, instructor in physics, graduated from Ohio State in 1937 and received his doctor's degree from Cornell in 1940; George F. Newbrough, associate professor in English. He is returning to the Norwich faculty after a leave of absence of two years during which he studied for his doctor's degree at Harvard where he received his master's degree in 1928; Sidney P. Welton, instructor in mathematics, graduate Acadia University, 1939.

Syracuse University. John A. King, Professor of Mechanical Engineering at the University of Kansas, has been appointed Professor and Head of the Department of Mechanical Engineering. George C. Ernst, Assistant Professor of Civil Engineering at the University of Maryland, has been appointed to a similar position at Syracuse.

THE ENGINEER IN A POST-WAR WORLD

By H. T. HEALD

Vice President of the Society

War today is a technological phenomenon. It is a war of design, research, construction, and operation as well as one of economic and military mobilization. The compelling force of national self-preservation brings into action every possible weapon, so that an emergency, such as our present one, becomes a measure of our current technological potentialities. We now know the place of the engineer in a war world. What that place will be in a post-war world can be only a guess, for no one has all the answers and many authorities disagree on the ones they have. Nevertheless, education must anticipate the future even in the critical present if it is to develop the leaders of the future. There are some guideposts to conditions in a post-war world—and they point to the engineer as the sine qua non of our post-war civilization.

Colonel Willard Chevalier, publisher of *Business Week* and a prominent engineer, in a recent speech in Chicago, gave a logical interpretation of future America in the post-war period based upon his panoramic view of our present war economy. Colonel Chevalier's prophecies are convincing because, as a competent observer of American business and industry, he "can see many parts without being too close to any one of them." He predicts that we shall have to make jobs for all workers who are competent to fill them. "We shall have to maintain in this country a continuing armament industry as a permanent element of our economy. I see," he said, "130 to 140 million people who are going to want things . . . increased supplies of basic materials that have been developed during this emergency . . . large, available labor supplies with a larger proportion of skilled men than before." New productive facilities must be converted to peace-time purposes—an operation that will create a large demand for capital goods. "And, on top of all this," he observes, "I see new efficiencies and new levels of management efficiency, which will be achieved under the whip of the present urgency."

Colonel Chevalier is certain that we shall be living in a vastly more difficult world. Competition in trade will be keener and far greater effort will be demanded for far smaller reward. "We are going to be living in an economy with a large overhead public debt.

That," he pointed out, "will mean a heavy tax burden as an element of cost. The influence of labor will be greater than ever before and wages will be higher. The suspended and distorted markets of normal times will have to be rebuilt and reshaped."

It is obvious in the present emergency that the importance of the technical man is far greater than it has ever been. According to Colonel Chevalier, the technical man is not only the author of our progress but is to be the author of our survival. Technology has created a higher standard of living in the past, but its future task must be to preserve the American traditions of democracy, free enterprise, and the capitalist system.

If the post-war world is to be as Colonel Chevalier visualizes it; and it is reasonable to believe that it will be; upon our future engineers will fall the burden and the privilege of preserving and enriching our American institutions. The responsibility for training our engineers to meet adequately the challenge of post-war conditions is that of our engineering schools. We must begin at once to analyze our curricula and teaching methods in the light of these post-war problems. We must discover the means to select and develop the highest type of technologists in the research field as well as in design and operation. And, above all, we must train men to a degree of efficiency in management heretofore unattained. They will need sound training in fundamentals to analyze and solve complex problems under constantly changing conditions. We must teach them to approach each new problem with an insight into its social and technological implications. And finally, we must help them to develop the vision and the imagination that are so essential to the uninterrupted march of technological progress. If the young engineer of the future has the responsibility of solving the intricate problems of a post-war world, then it is our duty as engineering educators to make certain that he has adequate tools to accomplish the job.

COÖRDINATION OF INDUSTRY WITH ENGINEERING COLLEGES*

By WALTHER MATHESIUS

Vice-President, United States Steel Corporation of Delaware

As I view the title of my assignment: "Coördination of Industry with Engineering Colleges," I am frank to admit that my definition of coördination may not necessarily be the most precise. As I conceive it, it presupposes the existence of one or more problems of common concern and this, in turn, leads to the finding that such coördination logically implies mutual aims and interests. Certainly, industry owes much of its progress to the technological advances which have resulted from the skill of your engineering graduates to apply in practice the scientific facts and the knowledge which you taught them, and industry is happy to acknowledge this debt. Since engineering colleges, on the other hand, exist largely because of the demand by industry for their graduates, they should be conversant with industry's current requirements and be prepared to meet them.

It is not my intention to discuss any specific technical or engineering course, or its adequacy, for fulfilling the expectations of a particular industrial field, but rather to consider college education in a broader sense which assumes a scope substantially wider than the exact curriculum or science itself. My viewpoint is concerned with the need for more adequate training of students at engineering colleges in the fundamentals of knowledge and logic, so that in later years they may advance creditably from a strictly engineering activity to administrative and executive positions with a maximum of advantage and continued benefit from the teachings of their college years. I find, in my own practical experience, that the effect of premature specialization in studies for a particular field often clings to the individual in business life and tends, in numerous cases, to limit severely his scope of usefulness and his advance to positions of greater importance in industry. Because engineering courses deal with exact sciences and problems, it might be assumed that the very nature of his early training in these subjects would tend to imbue the individual with unfailing logic and result in the training of men with marked analytical powers. It has been

* Presented at the 1940 meeting, Allegheny Section, S. P. E. E., Carnegie Institute of Technology.

my experience, nevertheless, that quite frequently the contrary trend exists. While these technical graduates may be able to solve specifically assigned and difficult engineering problems, their trained engineering minds tend to focus narrowly upon the designing, construction or production phases of their tasks and often fail to grasp the importance of essential economic, sociological and other fundamental relationships. Yet, it is frequently more important, in industry, that the needs for an improvement and its consequences, if made, be carefully and intelligently analyzed in their commercial, social and economic aspects rather than that the mechanics of the proposal be designed to the highest degree of perfection and precision. The latter task is as a rule quite capably handled by our graduate engineers, but the former requirement is apparently not so readily recognized by them. That this is due to a lack of inherent ability on the part of those engaged in the engineering profession is not conceivable since the fundamentals involved are certainly no more difficult to comprehend than the intricacies of many specific engineering problems.

It is obvious that engineers must be effective technologists, but it is also necessary that this profession, in order that it may render creditable services to the interests of the nation, be able to recognize and analyze correctly the many varied and complex economic, commercial or human problems which beset the majority of industrial developments today. The serious threats to their very existence, experienced by many branches of industry during the lean years of the recent past, have demonstrated forcefully and convincingly that it is not enough to drive for cost reductions and improved production methods, but that systematic attention must of necessity be given to public and industrial relations, to personnel administration and to research in these fields as well as in strictly engineering matters. Since all of these subjects must be considered as rightfully belonging within the sphere of technological influence, it is good logic that the steel industry is now taking a deeper interest in the activities of our colleges and in its mutual relationship and responsibilities with them, of which I should like to outline briefly, what appear to me as two important phases.

Firstly, I submit that one of the primary objectives of our engineering schools is the training of the growing generations to meet the future requirements of operation and management in industrial enterprise. Industry is, in a sense, an important customer for one of the college's principal products—a healthy crop of competent young engineers emerging annually from their undergraduate schools. Obviously it is desirable that there should be agreement between the colleges as producers and the industries as the consumers concerning the specifications for this output, just as they form a

proper basis for dealing in the more commercial commodities of everyday business. My contention is that industry's coöperation could go far in aiding the college faculty as well as the students, if industry would frankly state its conception of the essential qualifications for engineering graduates, and better still, if it would develop this conception by means of a thorough and continuous analysis of experience with its college trained personnel. While I am in no way authorized and perhaps only partly qualified to speak on behalf of the steel industry, I should like to present to you—as a personal good-will token—my own idea of a specification for engineers of college grade. It is my conviction that the essential objective of a higher education in engineering should certainly not be the graduation of specialists, but rather the building of good citizens, equipped with fundamental knowledge, and trained in logic. Completing his college studies should not become the end of, but rather the foundation for the young engineer's education for life, so that he will step out into the world able and eager to broaden his scope or, if he should desire later on to do so, to concentrate on a narrower field, in which he might then become a specialist and expert by choice and experience and not because of educational limitations.

I should like to urge my colleagues in the steel industry and my friends on the college faculties that they add their own statements of experience and recommendation to mine, in support or in rebuttal; and I suggest that these statements be submitted for the consideration of those who must plan and direct the curricula for our future engineers and managers. I am confident that coöperation of this kind will be welcome and helpful to industry, the colleges and the students.

It is obvious that under an educational program such as I have attempted to describe, our technical colleges could not be expected to supply from its graduating classes to industry engineers so completely and so thoroughly prepared as to fit them at once for responsible positions which usually require not only experience and skill but a substantial amount of further study whereby to develop proficiency in one or more specific fields. This is of course primarily a task which the young engineer must undertake on his own responsibility and for which he will be well prepared if he has learned during his college years, as he should have, the faculty of study. However, in fairness to him as well as in its own interests, industry must assume the obligation to provide adequate opportunity for such further development and study. I regret having to admit that in my opinion the steel industry has as yet made little progress beyond the bare realization of this fact. Too often are the college graduates who join our forces assigned to narrowly confined specific jobs from which they find it difficult to extricate them-

selves except by resigning and looking for a better chance elsewhere. Too generally is this post-graduate training of engineers in industry left to chance and far too few are the instances where systematic training programs and intelligent personnel management are actively and effectively applied.

It seems firstly, that help is required to convince industrial managers that there is need for action on their part, not only as a matter of fair dealing, but definitely in the interest of assuring to their own enterprises intelligent and effective operators and managers for the future. And secondly, I believe that industry, confused by apparent conflicts of interests and belabored by various pressure groups, needs fair and competent advice concerning the soundness of the principles and the propriety of methods in its personnel management procedures.

I venture the suggestion that you, the members of our college faculties, should be eminently qualified by reason of your impartial standing and your experience in education, to give such counsel to industry. Keeping in touch with the graduates of your schools, collecting, analyzing and reporting on their experiences, their progress and their recommendations for better ways of learning and doing more, you can, I believe, make a major contribution to the welfare of our industrial life, which should improve effectiveness in management and production and promote harmony in industry's ranks on the basis of just rewards to those sharing in its tasks with their hands, their heads and their savings.

And now I should like to point your attention to a second field of relationship between the technical colleges and industry. They can and will find more and more common ground, upon which to work as partners for the sole purpose of gaining knowledge and of applying it to the conversion of natural resources into goods and services.

The logical contribution of the universities to this phase of cooperative endeavor comes of course from their facilities and talent for fundamental research—from their opportunities for post-graduate training and for specialized technological courses. The industry's share in this picture, as I see it, appears on the background of a broad long range policy, which directs the conduct of the business in the interest of the common good and subordinates to this requirement the desire for immediate and selfish gains. This policy does not lose sight, however, of the necessity for profits, whereby to assure continuance of the enterprise and to provide for improvements as well as for support to still further search for greater knowledge.

Undoubtedly there are industrial concerns which because of their scope or their position in a given field should undertake fun-

damental research work in their own laboratories and with their own staff, and some of these have done so creditably and with notable results. This does not, however, in my opinion, alter the fact that the greater share of the responsibility for searching out basic truth impartially and scientifically must always be assumed by our learned institutions.

But even under this arrangement, industry cannot permit itself to become a silent partner and to relinquish the active pursuit of this never-ending search to the universities. Industry must always provide through its own facilities and personnel, for the essential continuity to link fundamental research to applied technology and this in turn to practical operations and results. Theory and practice are thus joining hands more securely in the steel industry, which is learning to appreciate the value of scientific approach to production problems and the necessity for adopting, in place of the old trial and error routes, modern means for the impartial and precise determination of the relationship between cause and effect. In the steel industry, as elsewhere, not only management, but particularly the rank and file is at times apt to discount the experiences of the past and take the present for granted, as rightfully theirs. However, even among those who toil with their hands the recognition is dawning today that the future of their livelihood is linked definitely to that of the industry and that the welfare of the latter cannot be made permanent by dictates of law or by restrictive agreements on output, employment and development. They are making a major contribution to harmony and effective performance in the steel industry by conceding and supporting the value of scientific knowledge in partnership with training and experience. For over-all success this coördination is essential as much as courageous, competent and conscientious management leadership. Together, they give us, in my opinion, a far better assurance for the future of our economy than could be realized under any other social order, no matter how glowing its promises might be for the pot of gold at the end of the rainbow.

These mutual interests and mutual responsibilities place definite obligations at the doors of industry and colleges and neither have been remiss in their attempts to fulfill their commitments. Nevertheless, I do not believe that the greatest degree of success in coordination can be realized for the common good until a strenuous effort is made by both sides to understand fully these mutual relationships in the service of educational as well as technologic advancement and to agree on the manner in which these objectives will be obtained. It is my personal opinion that industry can go somewhat further than it has up to the present time in developing ways and means for effective coöperation with engineering colleges.

I suggest that in addition to the various avenues now utilized to this end, representatives of industry might more frequently visit the educational centers to acquaint themselves at first hand with the problems which you face and also to convey to the students as well as the college faculty their conceptions of the needs and prospects in industry. For example, I believe that many executives and others in responsible industrial positions would be willing to give of their time as far as they can, to meet with the students and the faculties for informal talks on specific engineering subjects as well as on the broader aspects of industry's requirements from educational colleges. I suggest further that, in addition to this type of contact, arrangements be made for similarly informal meetings concerned with other phases of world affairs and our national life. This would, in my opinion, be a rational means of directing the student's attention to other essential elements of present-day civilization, which may be remotely beyond the scope of his engineering courses, but which he should learn to understand so as to broaden his grasp of humanity and his appreciation for the wonders of our universe.

And in conclusion, might not the desired coördination be more readily consummated through efforts made conversely also by the members of the college faculties, to call more frequently at industrial centers and in the workshops, there to take the initiative of inquiry and of discussions on the problems of both sides with men in industry and in public life? From such excursions into the whirl of productive and competitive activity you would bring home not only facts and figures, but often evidence of lacking knowledge, of bias and confusion, challenging your powers of impartial observation and scientific analysis. You would find there encouragement for your efforts in research, in teaching, in your written or spoken contributions to the scientific literature and technical wisdom.

Leaving this suggestion for your consideration may I express the hope that continued frank discussion may stimulate thought and action, aiming for continued development rather than for sudden changes to serve a passing need or to meet a present emergency. Only through sustained interest and effort can the coordination of industry with engineering colleges become complete and lasting, and that is for both an essential requirement of preparedness for distinguished service to our country and to mankind. Your S. P. E. E. can and will have an important share in this endeavor.

EVOLUTION OF AERONAUTICAL ENGINEERING EDUCATION *

By M. J. THOMPSON

Graduate Professor of Aeronautics, The University of Texas

In this day of greatly increased tempo in all industrial activities and a generally chaotic condition in world affairs, it may be presumptuous to ask for time to consider the development of aeronautical engineering education and to reflect on its shortcomings if any exist. The aircraft industry, however, has been more seriously affected than any other by the development of the Defense Program. The rapid changes occurring in the industry appear to justify the giving of careful consideration to our engineering training so that we may be certain of keeping abreast of the tide.

As a first step in this discussion, it seems proper to consider the development of our aeronautical educational programs to their present state. Michigan and Massachusetts Institute of Technology were the pioneers in the field. In these early days, it was natural that there should have been a heavy emphasis on aerodynamics as the basic science of mechanical flight. Little knowledge was then available and the design of a new airplane often raised many questions as to whether it could be flown, maneuvered and landed without disaster. Problems of stress analysis also had an important place in these programs, gradually increasing in significance as more and more of the tools of applied mechanics were developed and made available. In these early days it was not uncommon for an airplane to be designed by one man, with possibly a handful of assistants.

As knowledge of aerodynamics, strength of materials, and the theory of elasticity has increased, it again has been a rather natural thing for these courses to grow in content and significance. At the same time, however, the character of this expanding industry has changed in many ways. In the past few years, particularly, more attention has been devoted to design problems, not from the standpoint of aerodynamics and strength alone, but including a consideration of manufacturing processes and many related phases of production engineering. Industrial emphasis has changed so that aerodynamics and stress analysis now represent about 2 to 5 per

* Presented at the 49th Annual Meeting, S. P. E. E. (Aeronautical), University of Michigan, June 23–27, 1941.

cent of the personnel of an engineering department as against as many as 40 per cent in general design work.* The number of man-hours of work † involved in the complete design of an airplane is now so great that it is entirely outside of the realm of reasonable possibilities that such a project should remain or even approximate the early state of a one-man enterprise.

Another instance of the emphasis on aerodynamics in particular in the early development of aeronautical engineering training is the building up of wind tunnel laboratories in practically all of the pioneer schools and colleges. These laboratories have, without question, made many noteworthy contributions to the science of aerodynamics and its application to the arts of airplane design. Unfortunately, however, a situation has been developed which encourages the building up of such laboratories as a first step in the program of every college which proposes to enter the aeronautical field. While a wind tunnel laboratory is a most useful piece of equipment for aerodynamic demonstration work, its operation as a research laboratory should properly be considered as a part of graduate instruction. The development of a high percentage of aerodynamic research men in an undergraduate program seems to be definitely out of line with the needs of the industry. Finally it might be stated that in the building up of a new aeronautical engineering program, a school should certainly include provision for a wind tunnel of some form as a part of its equipment, but it should be pointed out that the possession of such equipment does not necessarily insure the obtaining of a well rounded and reasonably complete course of instruction.

A somewhat similar criticism might also be made in regard to the specialized work in stress analysis of which the average aeronautical student has been given an inordinately large dose. The emphasis on this subject in college training again appears to be considerably out of proportion to industrial requirements.

It is not proposed in this discussion that there be any weakening of that part of our work which trains the student in the fundamental sciences of aerodynamics and applied elasticity. Certainly the development and growth of a student into a true professional engineer must rest on a sound foundation of the basic subjects of fluid flow, strength of materials, and the like. My primary suggestion is that we need to give careful consideration to the emphasis placed on such topics and to the inclusion of highly special-

* C. T. Reid: "What the Aircraft Industry Expects of the Engineering College." JOUR. ENGR. EDUC., March, 1941.

† R. Randall Irwin and Jacob Kadushin: "Training for National Defense. IV. Training College Graduates for the Aeronautics Industry." *Mech. Engr.*, March, 1941.

ized and advanced treatments in an undergraduate program. The facts are that a very large percentage of our students will make very little if any use of such training in the early years of their professional careers. Furthermore these subjects are often so highly mathematical in character that their presentation to undergraduates may becloud the basic physical concepts which these students should understand. They are unable to see the forest because of the trees.

The statement that we may be guilty of overemphasizing in our undergraduate program the specialized and advanced aspects of aerodynamics and stress analysis, leads us to suspect that certain other phases of our work may be somewhat neglected. It is my opinion that this is particularly true of the broader subject of airplane design. A considerable amount of discussion of this topic has recently been put before us, the general theme being a complaint from industry that our student product too frequently possesses no clear concept of the function of the design engineer. The papers of Irwin and Kadushin and Reid, previously referred to, are representative of those which bring out this point very strongly. The multitudinous discussions of machine design which have appeared recently in many technical journals are still further evidence of the same general type of criticism applied to a broader field.

My own philosophy of the role to be played by design work in any engineering course is that it should fulfill two primary functions. As a preliminary it might be well to emphasize the fact that design is more often an art than it is a science, yet its tools are very definitely scientific in character. The criticisms previously discussed might be summarized by saying that in the effort to sharpen and increase the effectiveness of such tools as aerodynamics and stress analysis, we have too frequently lost sight of the purpose for which these tools are to be employed.

Now the first of the two main functions of a design course might well be to acquaint the student with representative modern design work, in other words to give him a picture of what is being done in the industry. Such material should properly be critical as well as merely informative. Along these same lines, the student should be acquainted with modern drafting room techniques, methods of designating Army and Navy standard parts, and other such matters which may seem to be inconsequential details but which will certainly make him more immediately productive when he first enters the industry. Design and drafting room manuals of the Army, Navy and the airplane manufacturers are particularly helpful in this respect and all of these organizations will be found

to be more than anxious to coöperate. Sketches of details of new designs, given in the technical journals, and samples of various airplane parts, for at least some of the smaller units are of considerable benefit. Supervised inspection trips to aircraft factories are especially beneficial and it is hoped that the continued coöperation of the Army and Navy may be had in securing admission to plants contributing to the Defense Program.

The second phase of design training is the opportunity it provides for the correlation, emphasis, and application of the scientific tools with which the student presumably has been provided. The student should be given an opportunity to make use of the aerodynamics, stress analysis, and other topics which he has been studying. At the same time an appreciation of the creative aspects of design as contrasted to the synthetic nature of his tools can be emphasized. The practical aspects of design from the standpoint of manufacturing processes, production methods and the economic factors in commercial work can well be brought home to the student in such a course.

The general outline given above represents something of an ideal which naturally will require modifications because of limitations of time, if for no other reason. Careful planning of such a course is certainly required and the desirability of close contact between the instructors and the industry is particularly important. The coöperation of the industry in offering summer employment to qualified instructors is worthy of much commendation. It is perhaps too often the case that airplane design instruction is treated as an orphan and is not given the attention and careful planning that its importance indicates it should receive. Where this is the case, it is not surprising that the industry complains about the lack of training in design of the student coming directly from college without any industrial experience. The attitude of many senior students looking for jobs toward drafting and layout work is another indication that all is not well in our instructional program. Too often they have a feeling that they will be "stuck on the board" as a tradesman and have no appreciation of this type of work as an apprenticeship for the broader and more advanced aspects of design.

Industrial training courses, such as have recently been developed by some of the larger aircraft companies, are an effective means of bridging the gap between academic training and industrial practice. It is believed, however, that much can be done by the engineering colleges in narrowing this gap and in training students who are better equipped for productive work than those who are now graduating. It is doubtful if the college program can ever completely eliminate the need for industrial training but certainly

our students should begin their industrial careers with something more than the development of the absorption qualities of a sponge.

In conclusion, then, I should like to ask for a review of aeronautical engineering programs from the standpoint of reducing in the case of undergraduate work, at least, the emphasis placed on the more specialized aspects of the tools of the designing engineer. If more time and attention are devoted to training students in the use and application of these tools and in the broader aspects of airplane design, I believe that we may more justly be proud of the product we are supplying to the aircraft industry.

S. P. E. E. MECHANICAL ENGINEERING DIVISION

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TEACHING METHODS IN SANITARY ENGINEERING*

By WILLIAM C. HOAD

Professor of Civil Engineering, University of Michigan

For the purposes of this paper, Sanitary Engineering may be considered as the application of the science and the arts of the engineer to the creation and maintenance of physical conditions conducive to healthful and comfortable living. In accomplishing these purposes sanitary engineering works on the environment rather than on the individual person. It deals with communities rather than with their inhabitants, with cities rather than citizens, with industries rather than workers. In general, its operations are wholesale rather than retail.

To attain its ends sanitary engineering uses the great agencies of water supply and water purification, of sewerage and drainage and the treatment and disposal of sewage, of city refuse collection and disposal and the maintenance of clean streets, of the reclamation and improvement of the waters of lakes and streams. It demands a part in community and regional planning, it extends its influence into housing and into the formulation of building codes and zoning ordinances, it carries a fundamental part in the achievement of industrial health and safety, it lends a hand in maintaining the purity and cleanliness of the common atmosphere of cities and it contributes to many other forms of general environmental sanitation.

In carrying on his work the sanitary engineer comes into cooperative relationships with various other professionals, for his functions overlie many technical fields. He must work with the district and city planner in their great work of coördination, with the architectural and structural engineer on housing, with electrical and mechanical and chemical engineers in the lighting and ventilation of public buildings and in many phases of industrial sanitation, with the hydraulic engineer in the control and improvement and utilization of natural waters, and with public health officials everywhere and of every order of magnitude.

Whether he acts independently from a private office, or as an officer of government, or as a corporation official, he deals with mayors and managers and directors and superintendents, and with

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councils and commissions and boards in great variety. His professional engagements are rarely with individual persons, but nearly always with some governmental or industrial organization.

These relationships are mentioned here only for the purpose of emphasizing the direct and vastly important social aspects of sanitary engineering and to suggest an approach to a consideration of teaching methods in this field. It is indeed these inherent social relationships that give to sanitary engineering its peculiar attraction as a lifelong study as well as its recognized value as a matter of public concern. There is nothing compellingly interesting about the remedial treatment of city sewage or the improvement of water pumped from a dirty river, nor in the never ending task of maintaining clean streets, nor in the fight to keep smoke and ashes out of the air supply of cities. There is little inherent attractiveness in any job of repairing the damage done by others.

It is the social implications of these rather prosaic activities that give them their value and entitle them to high rank in the list of things that must be done. These are not matters merely of increased dividends or of money profits, or of convenience even, or of pleasure. They are matters of life or death, of health or disease, of wholesome or unwholesome conditions for living and working.

These social implications ought always to be recognized and accorded their proper rating in the teaching of sanitary engineering. Adequate treatment is everywhere given to problems of structural soundness and usually also to those matters having to do with functional integrity and dependability, while any question to which the dollar sign may be attached is almost certain to receive exaggerated consideration. Surely the fundamental social objectives toward which sanitary engineering is directly aimed and the fitness of its various devices for their intended purposes should be at least equally regarded.

The subjects making up the usual curriculum in sanitary engineering may for convenience be put into three groups. The first group may be taken to cover the broad fundamental sciences upon which all engineering rests together with other preparatory subjects generally included in all engineering programs. The second group may properly include certain fundamental subjects which are more specifically related to sanitary engineering or which contribute some peculiar value to the curriculum in that field. The third group will then comprise those special subjects which deal primarily with the practical application in the field of sanitation of principles learned earlier.

Methods and practices in the teaching of mathematics and physics and chemistry, of English and foreign languages, of economics and other social studies, of surveying and drawing, of statics and

dynamics, of the techniques of structural design, of roads and pavements and of transportation by rail and water and highway need not be any different from those deemed best for civil engineers in general. Perhaps the writing of engineering reports and the subject of municipal government should receive unusual emphasis in the instruction of sanitary engineers. Also in chemistry some special attention should be given to the chemical and physical behavior of both mineral and organic substances in the vastly attenuated solutions represented by natural waters and to the effects of temperature and other physical conditions upon the speed and completeness of chemical reactions in such dilute solutions.

Somewhat analogous suggestions might well be made about the teaching of physical geology and of topographic surveying. The origin and meaning of surface features in geology, together with their significance with respect to engineering structures, and the role both of surface waters and of ground waters in producing geologic forms are matters of high importance in sanitary engineering. In the surveying field there is need for more adequate instruction in the broad topography of large areas—such as entire suburban communities or the natural watersheds of streams—and in the evaluation and use of airplane maps.

Among those subjects that are more specifically related to sanitary engineering two or three may be singled out for particular suggestions. In bacteriology nearly all the books used in teaching are either texts designed primarily for medical students, in which the attention of the student is quickly narrowed down to a comparatively small group of pathogens, or manuals for the training of laboratory workers. For sanitary engineers more emphasis should certainly be given to the normal saprophytes of soil and water. Also, specific attention should be given to the behavior and ultimate fate of these saprophytic forms, and of some pathogenic forms as well, when widely distributed through the waters of streams or lakes and subjected to the thermal and osmotic and other physical conditions found in such waters.

Hydrology should give suitable attention to ground water movements as well as to the discharge patterns of surface streams. More consideration also should be given to the hydrology of lakes, reservoirs and other quiet bodies of water. It would be immensely valuable too if the study of this subject could be extended to include something about the physical and chemical changes that take place in the qualitative character of the water, in its progress from rainfall and melting snow to final discharge, along with its quantitative variations, but perhaps this is too much to ask for. Such a study, moreover, would quickly lead over into the closely related field of rheology and limnology.

Perhaps a third comment may be ventured here. Sanitary engineers have to deal extensively with water, and in a great variety of ways and for many different purposes. It is especially important for them to have a good understanding of the various phenomena of water when in motion, whether flowing in natural streams or prepared channels or manufactured pipes, whether falling over weirs or speeding through orifices or spouting from nozzles, whether moving quietly through settling tanks or percolating through beds of sand or trickling over the gravel stones in filters. It is a valuable aid to the students in arriving at such an understanding to have these phenomena expressed in simple terms and with symbols that are related as definitely as possible to the substance of water itself. From this point of view the recent tendency in engineering colleges to treat hydraulics as merely one aspect of a generalized fluid mechanics seems unfortunate.

In teaching about the application of the engineering sciences to some practical purpose the purpose itself should be held clearly in view. Too often the purpose is lost sight of in the pleasant occupation of juggling with the scientific tools in hand. The broad subject of community water supply, for example, may be made to yield quite an array of intricate and time consuming, but nevertheless essentially third-rate, problems in hydraulics, and it is easy to occupy the student's mind during a good deal of the course with things of that kind. But a city water supply system is not merely an orderly assemblage of pipes and pumps and filters and reservoirs. It is a great public utility empowered and protected by law and custom but charged with corresponding duties and responsibilities, the most vital of all the great utilities by which the city is served and chief among the three or four that make it possible to have a modern city at all. Surely these broad community relationships are of more importance for study than academic problems about the flow of water through branched or compound pipe lines. But the actual functioning of the water supply system and its fitness for the needs of the community which it is destined to serve usually receive only scanty attention.

Many of the things the sanitary engineer plans are intended to be operating concerns, such as pumping stations, purification systems, and treatment plants of various kinds. In teaching students about these things more emphasis should be laid on the performance of such plants and on their fitness for the job in view. Oftentimes they are talked about as if they were merely static structures, like a retaining wall or a bridge, instead of something akin to a manufacturing plant. Charts and diagrams setting forth clearly the operating results of such plants—not primarily the dollar cost of operation, although this may be an important ele-

ment, but the real performance of the plant in accomplishing what it was designed to do—these are helpful aids to good teaching.

Inspection trips to nearby plants in normal operation are, of course, well recognized aids in visualizing the meaning of text-book principles. Such trips are most valuable when considerable attention is paid to what the plant accomplishes, as well as to the interesting structures and equipment on display. But the legitimate purpose of these inspection trips should not be made over into some intricate problem in the collection of data such that the student has to spend all his time ducking about with pencil and notebook in pursuit of rates, capacities, dimensions, design units and what not. These things, if important for the study, might better be furnished to him in advance. What the student most needs on inspections such as this is time to sense the nature and effects of the treatment processes, and especially to follow through the plant sequentially from beginning to end. Also, he should not be talked to all the time he is there.

Even in the classroom study of these various operating systems attention should first be focused on the processes employed rather than on the structures and equipment by which the processes are promoted or controlled. When the processes themselves are well understood the proper design of structures will follow almost as a matter of course. But the cart sometimes gets before the horse and there is too much aimless engagement with settling tanks and filters and too little study of sedimentation and filtration.

This tendency to be preoccupied with structures and machines seems most pronounced, and most unfortunate, with respect to those processes in which biological agencies are largely involved, such as the oxidation phases of sewage treatment. Here the structures are quite meaningless if considered without reference to the intense biological activities that go on in them. It is putting the emphasis in the right place to look upon a trickling filter, for example, as primarily a workshop for keeping a sufficient number of certain kinds of bacteria at work, under conditions favorable to their best activity. From this point of view questions of air and food supply, of colonizing areas, of the hydraulics of sprinkling systems, of waste removal, of loading and overloading and of the time factor are readily understood as fundamental biological requirements which must be reflected in such structural features as depth, size, underdrains, distributors, and the like. The structural design thus rests squarely upon the functional plan.

Teaching devices for implementing teaching methods are as various as the methods themselves. Mention may perhaps be made of a few which have shown a considerable degree of usefulness.

Maps of the entire watersheds of familiar streams, accompanied by stream profiles and by diagrams showing seasonal patterns of stream flow, are useful in a variety of ways, especially when they visualize the actual or possible uses of the stream for water supply, recreation, power, waste disposal and other purposes.

Diagrams showing water consumption rates in cities of different types and sizes are extensively employed and are highly useful. Such diagrams should include not only statistical averages and long-term trends but also general seasonal patterns and daily and hourly variations. Capacity ratings for a water supply plant have to be derived from such diagrams as these, and different elements of the plant have to be designed for different peak cycles and peak durations. The water supply engineer cannot pick his live load formulas out of a handbook.

Performance diagrams showing the operating results of water purification and sewage treatment plants, and of each individual process involved, are extremely helpful in the study of various process combinations.

General process diagrams for some of the more complex treatment systems aid in the study of process sequence and also of plant arrangement. Diagrams of this kind are helpful also in directing primary attention to the purification process, rather than to the plant structure.

In teaching advanced students in sanitary engineering considerable use can be made of folios of construction drawings showing in detail the forms and dimensions of the various structures, but to the ordinary class of undergraduates such details are merely confusing.

Pictures projected on a screen in front of a class are extensively used and are valuable if kept fresh and up to date. Lantern slides, because of their high cost and their durable nature, tend to be employed for periods far beyond their useful life, however. Lantern slides ought to be made of some material that will suddenly become opaque after about ten exposures to strong light in an atmosphere of chalk dust. For most classroom purposes balopticon pictures, to be thrown on the screen by reflection, are preferable merely because they can be replaced with newer and better ones more easily. Illustrative materials are thus more likely to be kept up to date.

SCIENCE AND TECHNOLOGY IN THE ENGINEERING CURRICULA CONTRIBUTIONS OF WORK EXPERIENCE*

By OVID W. ESHBACH

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"Experimenta Docet" is an old Latin motto and truth which has been accepted as an axiom. The teaching function of experience is the heart of the coöperative idea, just as science and technology characterize engineering education.

Both of the terms experience and teaching have broad connotations. No two human experiences are alike in the sense that the same observations and reactions result. History is a record of past experience much of which lacks the stimulating force of a personal witness. It is valuable in establishing a social perspective and when studied in correlation with social science has predictive value for future prophecy and action. Physical science differs largely in being more specific, more capable of reproduction, study and formulation, but it is still a record of experience. Technology is the application of science to special commercial objectives, relatively easy to formulate and repetitive in character. Mechanics of materials and construction practices, the science of electricity and the transmission of power and intelligence, organic chemistry and petroleum production, the science of heat and thermodynamic application, and fluid mechanics and aerodynamic design are typical examples of relations between science and technology.

In the early development of coöperative education there was the ideal of stimulating the transmission from science to technology by work experience. For obvious practical reasons a time correlation cannot be planned. If it were possible—and sometimes it occurs —it would be an ideal way of developing applied scientists, but I doubt its value as the best way of developing engineers.

To be more explicit, it is appropriate to say something about the nature of engineering education as distinguished from training in science and technology.

All education has the general objectives of imparting knowledge and developing power or skill in performing the many and diversified social tasks which our complicated society requires. Cultural

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objectives go beyond the effective performance of these tasks and aim at the achievement of the most ideal human relations. A well balanced education embraces knowledge, skill, and culture. In a broad sense, degree of emphasis and definiteness of objective are the only things which differentiate trade, professional, and general education. To assume that any or all of them must be acquired through formal institutions is to deny the educational value of experience.

Engineering is a form of professional education. Its group is defined particularly by special knowledge common to all and the character of skill acquired. As in other professions, individual success depends upon ability to cope with a multitude of diversified problems which arise continually and require rapid and accurate solution. Thus its value is not to be measured alone by the quantity of information acquired but also by the flexibility and versatility with which it develops. The vital requisite is a disciplined mind, with the perspective, the judgment, and the ingenuity necessary to derive the greatest possible value from the information available. This is so generally characteristic that unconsciously the term "engineering" is popularly applied to many acts which require skillful planning and execution, even though they are unrelated to science and technology. In fact, the generic meaning of the word is derived from the Greek meaning *ingenious*. It is only by a trick of etymology that it has become associated with engines. Consequently, it is of great importance, at the beginning when the foundations of science and mathematics are taught, that strenuous efforts be devoted to creating the facility for clear, logical and rapid thinking. The discipline and habit-forming functions of regular employment in industry contribute at an early age to the subsequent accumulation of factual knowledge and the cumulative development of an alert and well-conditioned mind independent of the kind of experience to which students are subjected.

Thus coöperative education achieves the objective of a powerfully effective program of training in the most direct and comprehensive way. The student looks at the field of engineering not only from the narrow viewpoint of the technologist who devises machines and methods, but also from the practical viewpoint of the doer who translates them into action. This combination of theoretical training and experience invites and encourages a correlation which may not otherwise be possible or expedient, and which contributes considerably to the value derived from each. With principles of science fresh in mind, the student takes his place in industrial activity, where the value of particular knowledge and a broad understanding of numerous apparently unrelated fields is impressed upon him.

His period in industry completed, he returns to college and finds that his academic work assumes a new and interesting significance.

While in its broader philosophic aspects this characterizes the dynamic contribution of early work experience, it is by no means limited to this significance. Engineering is segregated into divisions. They are a heritage of experience and maintained by tradition and vested interest both professionally and educationally rather than industrially. These divisions are differentiated from one another by selected fields of technology.

So long as our present provision for professional specialization exists, coöperative education will be expected to enhance technical knowledge in traditional courses. While it is not an absolute essential that civil, electrical, mechanical, and chemical engineers' work experience be in their chosen field, it is desirable, and aside from the knowledge acquired, contributes to the morale of students who have prematurely fixed their attention on specialized fields.

Much of experience is haphazard and opportunistic in character and the most loosely organized experience can hardly fail to contribute both to professional maturity and breadth of knowledge. On the other hand, improvisation is a very doubtful way of action.

What is the best plan to insure the maximum contribution of work experience to the scientific and technological stem of engineering education? I hold the opinion that successful coöperative education does not depend upon any one plan. The common divisor of all plans is a philosophy rather than a method. It assumes the inseparability of technical education and industrial activity.

On the other hand, if conditions would permit free choice of method I should incorporate these essentials in a well organized plan.

1. I would select only those students who showed promise of scholastic success and later professional achievement.

2. To insure the full content of technical instruction of a standard acceptable to the profession, I should choose a five-year plan in which at least the first year would be spent wholly in academic work.

3. I would organize the same courses of instruction for all during the first three years.

4. I would aim during the first half of the students' experience to develop an awareness of the synthesis of technology in industry, habits of study, self-discipline, and industry on the part of the students, and so supervise their placement that the maximum stimulation to learn and work would be achieved in this time.

5. During the last two years of their experience I would make every effort to place students where their experience would con-

tribute most to technological achievement consistent with their desires.

6. I would be fair and considerate in making concessions to industry to insure continued and whole-hearted coöperation.

7. I would arrange the periods of work experience to best meet the wishes of the coöperating industries.

If nothing more were attempted such a program would command the respect of education and industry. Those who are experienced in the administration of coöperative courses know that this is only a part of the opportunity that is naturally inherent in the plan.

A very important by-product is the enrichment of the technical content of curricula by situations and problems brought back from experience. Wherever seminar courses are organized the standard of papers and educational stimulation is raised to a level unattainable elsewhere. The advantage to the staff is obvious. It not only requires an alertness above the average but adds vitality to the whole program of undergraduate instruction. Stimulation of graduate study and research is a natural sequel.

One of the most frequently overlooked results is the influence of the more advanced students upon the attitude of the underclassmen. Too frequently opportunity for the full play of this influence is denied by overcrowding the curricula. I see little justification for assignments requiring more than the normal engineering schedule even though a higher working efficiency is obtainable. Opportunity for social functions and extra-curricular activities in moderation and also free electives in non-technical fields are as important as highly developed specialization for the majority of undergraduates.

In this discussion I have deliberately chosen to adhere to generalities. The teaching of experience comes in a different way. It comes in bundles of disconnected or isolated events and it would have been characteristic had I chosen a presentation of clinical examples to have shown some of the influences of work experience both on the development of individuals and its contributions to technical knowledge. These are legion.

STATISTICAL BASIS OF THE QUALITY CONTROL PROGRAM *

By S. S. WILKS

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1. Introduction

Under the leadership of W. A. Shewhart, Bell Telephone Laboratories, statistical methodology is becoming more and more widely recognized in industry as an effective tool for dealing with certain problems in mass production, particularly those arising in inspection and quality control. Applications of statistical methods are also being made in connection with industrial research and development work. In their search for the underlying causes of variations in raw materials and manufacturing operations, quality control experts have been forced into a statistical treatment of certain problems. They have found that efficient standards of quality cannot be set up arbitrarily without making systematic use of observations relating to the materials and operations. It is through the study and interpretation of these observations by means of modern statistical techniques that they are able to help the engineer locate and eliminate causes of excessive variability in materials and processes and thus arrive at a controlled state of quality.

Before proceeding further it will be well to state more precisely what we mean by the terms quality and statistically controlled state of quality. Before statistical methods can be used we must have some quantitative definition of quality. For example, suppose we are interested in resistance in telephone relays as a quality characteristic. For a given relay a measurement of resistance can be made with standard instruments. This measurement is a number expressed in certain units (ohms) and it will vary from one relay to another; in fact it may vary slightly from one reading to another on the same relay. It is in the examination of variability within series of measurements of this type that statistical methods come into the picture. In producing telephone relays on a mass production basis it is certainly desirable to eliminate variations in resistance as much as possible, economically

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speaking, by locating and weeding out the causes of such variations in the manufacturing process, and to make successive readings for different relays behave as much as possible like successive readings on the same relay. In fact it may even be desirable for proper relay performance to reduce the variability in successive readings on the same relay by making suitable changes in materials or design. When the variation in resistance readings for a series of relays as they come from the production line has been reduced to an economic minimum, that is to a stage beyond which the variation cannot be further reduced without drastic and expensive changes in materials, design, or procedure, we may say that a statistically controlled state of quality has been reached as far as resistance is concerned. A similar situation would, of course, be true for any other pertinent quality characteristic. It should be emphasized here that if we want to be precise in talking about the quality of a product, we must describe it in terms of measurable quality characteristics, and in general there will be several such characteristics. For example, the quality of a telephone relay cannot be described in terms of resistance alone, it must also be described in terms of capacity, inductance, and other characteristics. In dealing with the problem of quality control it has been found to be sufficient for practical purposes to consider only one quality characteristic at a time, although statistical techniques exist for handling several quality characteristics simultaneously.

With these introductory remarks we shall now turn to a more detailed, yet non-technical discussion, of the part played by statistical methods in dealing with problems of inspection and quality control.

2. Quality Control through Inspection at End of Production Line

The standard procedure for guaranteeing a given level of quality of a product as defined by specifications is by consumer or producer inspection. Many products are subjected to 100 per cent inspection while others are inspected by sampling. In the case of 100 per cent inspection there is no statistical problem except perhaps that of analyzing records of rejection percentages in an effort to find out why some rejection percentages are higher than others. The case of inspection by sampling, however, is full of mathematical and statistical problems. The necessity of inspection by sampling arises because of high inspection costs or because of the destructive nature of certain tests. For example, it would be very uneconomical to carry out a 100 per cent inspection program for shingle nails. Inspection of electric light bulbs to determine length of

burning life can obviously be done only on a sample basis. If a sample is to be used as a basis for inferring the quality of the products being turned out at the end of a production line, principles of random sampling must be followed if the inferences are to be valid.

Dodge and Romig * of the Bell Telephone Laboratories have devised sampling procedures together with appropriate tables for partial "screening" of defectives. The object of their method of inspection is to establish an "average outgoing quality" expressed as per cent defective which will not exceed a given limit, with a minimum of amount of inspection. For example, one of their schemes runs as follows: A lot of m pieces is up for inspection. A sample of n pieces is drawn at random from the lot. If the sample has more than an allowable number c of defectives in it, the lot is subjected to 100 per cent inspection, all defectives being corrected or replaced by non-defectives. If the sample has not more than c defectives, these defectives are corrected or replaced and the lot is accepted without further inspection. For a given m, and for a given upper limit L of "average outgoing quality" expressed as per cent defective, and for a given incoming per cent defective, a combination of values of n and c can be found which will involve a minimum amount of inspection and will insure that the average outgoing per cent defective will not exceed L. For example in considering lots of 1000 pieces, under this method of inspection, the use of samples of size 220 with an allowable number of defectives equal to 5 (*i.e.*, $c = 5$) will establish an average outgoing per cent defective which will be at most 1.1 per cent. This particular sample size and allowable number of defects would be the most economical combination for this lot size and level of outgoing quality for an incoming per cent defective in the range 1.2 per cent to 1.6 per cent.

Dodge and Romig have also considered various other sampling schemes, including double sampling for securing a given outgoing quality level with a minimum amount of inspection.

This method of quality control through sampling inspection at the end of the production line operates by partial "screening" of defectives and is clearly not applicable to situations in which inspection is destructive. In such cases a given quality level for outgoing batches or lots of products cannot be secured by screening out defectives.

* H. F. Dodge and H. G. Romig, "Single Sampling and Double Sampling Inspection Tables," *The Bell System Technical Journal*, Vol. 20 (1941), pp. 1–61.

3. Quality Control through Elimination of Causes of Variability. The Quality Control Chart

If sampling inspection is to be used for determining quality of outgoing products where inspection is destructive, the method must operate on basis of the principles of inference from random samples. If it is desired to raise the level of quality of outgoing product in such situations, it can only be done by altering the manufacturing process, and not by screening out defectives at the end of the production line. A systematic record of results of sampling from the production line will furnish a picture of the level of quality, that is whether it is under control or is fluctuating erratically. For the purpose of getting a running record of the state of quality of a given product the sampling method is applicable not only at the end of the production line but in various earlier phases of the production process. This particular application of sampling, and its use as a basis for taking action to eliminate causes of excessive variation in quality, has been highly developed by W. A. Shewhart * of the Bell Telephone Laboratories. The procedure has been set up in a graphical form known as a quality control chart.

Without going into technical details let us describe briefly the operation of the quality control chart scheme as Shewhart has developed it, in examining a given quality characteristic of a given product at a given stage in its production. A sample of let us say 100 product pieces is taken from the production line at the given stage in production, and the quality characteristic is measured on each of these pieces. These measurements are arranged in 25 subsamples of four pieces each in the same order in which they come from the production line. The four measurements in each subsample are averaged and plotted vertically against the subsample number. A horizontal line is drawn through the mean of all measurements and a horizontal *action* line is drawn at a distance of three standard deviations on each side of the horizontal mean line, the standard deviation being computed from the 25 subsample means. A practical rule has been adopted that if all 25 of the plotted points fall between the two action lines, the quality characteristic is regarded as being in a state of statistical control. If, however, one or more of the points falls outside the action limits, this is to be taken as evidence of the existence of a factor in the production process which is disturbing the quality. There remains then the engineering problem of tracking down the cause of the disturbance and eliminating it if it can be done economically. If it is either impossible or uneconomical to remove the cause, then of course its effect on quality must be accepted as a part of the

* W. A. Shewhart, *Economic Control of Quality of Manufactured Product.* D. Van Nostrand Co., 1931.

uncontrollable variation of quality. There is a small degree of probability that a point will fall outside the action lines when no assignable cause exists, but the choice of action lines at a distance of three standard deviations on each side of the mean line makes this probability negligible and at the same time does not place the limits so far apart as to cause disturbing factors to be very frequently overlooked.

After assignable causes of variation of the quality have been removed at this first stage, a new sample is taken, new action lines are set up and further efforts are made at removing causes of variability. After several successive stages of this type it is a matter of the experience of quality control chart users that a practical state of statistical control of quality has been reached, that is, a stage has been reached in which the causes of variability in quality are of such a nature that it is no longer economically feasible to remove them. After this controlled state of quality has been established some sampling is continued to make sure the quality remains under statistical control.

This quality control chart procedure is clearly applicable not only at the end of the production line but at various stages back in the production process. In fact the use of the method at several strategic places in the production process makes it possible to locate and remove trouble closer to its origin and before its effects have spread very far down the production line. The control chart provides a simple and effective method of making comparisons between different production lines, different workmen, different batches of raw material, different production times, etc., in so far as these factors affect the particular quality characteristic being considered.

Perhaps it should be remarked here that points falling outside of the three standard deviation action limits is not the only criterion which is being applied to quality control charts for detecting the existence of causes of excessive variation in quality. Another criterion which is being used particularly in industrial research and development work is that of runs, that is, unusually long sequences of high or low points on the quality control chart. Probability theory is used to establish critical lengths of runs in a given number of points such that observed lengths exceeding these critical lengths can be regarded as indicative of the presence of assignable causes of variation. For example, if a sequence of 40 points is obtained in a sample, runs of length 9 above or below the median of the sample may be taken as a critical length for practical purposes. In fact if no causes are operating to produce runs, the probability is less than 0.01 that a run of length 9 or longer will occur above or below the median. Thus, if the criterion of runs is taken as indicative of the presence of causes of

excessive variability in the form of runs and if runs of length 9 or more occur above or below the median in samples of size 40, the chances of falsely looking for trouble not present are about one in 100.

4. Tolerance Limits from a Statistical Point of View

When a practical state of statistical control for a given quality characteristic has been reached and is being maintained through routine checking by the quality control chart method, the variation in the quality has been reduced to a practical minimum. Under such conditions one is in a position to set up efficient tolerance limits for the given quality characteristic. To be more precise, if the quality is under control at a given stage in the production process and if a sample of several hundred measurements of the quality characteristic is taken from the production line at this stage, then one can take the spread or range of these measurements as providing a tolerance range within which practically all future measurements will fall, provided, of course, the same state of quality is maintained. One can even be mathematically precise in this problem and state for example that if a sample of 660 measurements is used the odds are 99 to 1 that the sample range will include at least 99 per cent of all future measurements taken under the given state of quality control. Larger samples will, of course, provide ranges involving greater degrees of certainty in both senses. Since the variation in quality has been reduced to a practical minimum in the controlled state, the quality range in the sample will on the average be smaller than would be the case if a state of control did not exist, and hence if the range in a large sample, taken under conditions of controlled quality, is used as the tolerance range for production, the tolerance range will be efficient in the sense that it is practically a minimum.

The usual rule in setting tolerance limits for a given quality characteristic is that they are set up in advance in a specification more or less arbitrarily on basis of the pooled experience of those setting the standards. If tolerance limits set up in this manner are used, the advantages of establishing a state of quality control are obvious. For, as we have seen, one result of establishing a given level of quality control is to minimize variation in quality around this level, thus minimizing the percentage of rejections, that is, the percentage of cases whose quality measurements fall outside the already-established tolerance limits. In trying to minimize rejections there is, of course, a natural limit beyond which it does not pay to go, namely where the rate of increase of cost of weeding out the various minor causes of variation in quality balances the rate of increase of savings from products rescued from rejection.

If full use is to be made of the results of statistical quality control, the setting of new tolerance limits and the revision of original tolerance limits should come in for their share of the benefits. If it can be demonstrated from samples taken from a production line in a state of statistically controlled quality that arbitrarily set tolerance limits are unnecessarily wide, it seems only natural from the point of view of efficient use of materials that they should be revised so as to be consistent with the actual results of production under controlled quality conditions.

There are many statistical problems involved in the setting and revision of tolerance limits on basis of sampling results obtained under conditions of controlled quality, particularly in connection with assemblages of pieces, which we cannot go into here.

5. Concluding Remarks

In this paper we have attempted to give a brief non-technical outline of the statistical background of quality control procedures, leaving to Professor Olds the task of considering some of the technical mathematical and statistical problems and techniques in quality control work. We have indicated that it is possible to control quality at the end of the production line in cases of non-destructive inspection by "screening" out defectives through sampling schemes. Practical sampling methods involving a minimum amount of inspection for a given level of outgoing quality have been devised by Dodge and Romig. A more fundamental system of quality control is to set up procedures at various points in the production process for locating and removing assignable causes of variation in quality. The use of the quality control chart as developed by Shewhart as a statistical technique for use in such a program has been described. We have touched lightly upon the matter of tolerance limits from a statistical point of view. These techniques and also many others which will undoubtedly sooner or later find their way into the quality control problems of mass production, are based on a well-known body of principles of probability and mathematical statistics. Thus far, these principles do not seem to have been very widely disseminated in the engineering world. Apparently there is a shortage of engineers familiar with statistical techniques. Some of the engineering schools in the country are recognizing the need of training in probability and statistics and are taking steps to make such courses available to their students. However, it is doubtful whether the statistical phases of the quality control problems of industry can be handled effectively on a wide scale basis unless there is a great increase in the proportion of young engineers now being turned out who are familiar with the principles of probability and statistics.

COMPARISON OF POSSIBLE NON-TECHNICAL SEQUENCES WITH TECHNICAL SEQUENCES IN THE ENGINEERING CURRICULA *

By W. OTTO BIRK

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When the Committee on Aims and Scope of Engineering Education said, in announcing its preference for "an integrated program of study extending through the entire undergraduate period," that "there are advantages in the parallel development of *scientific-technological* and the *humanistic-social* sequences of engineering education," it not only recognized the necessity of reducing the total time given to courses in the first group so as to provide room for those of the second, but it also implied two important questions about the second group, with which we are at this moment chiefly concerned. The first is "What courses should be included in the humanistic-social group?" and the second is "In what order should these courses be given?" If you recall the report, you know that the Committee did not ask these questions, but it must have had them in mind, because we know that when we get down to the difficult, practical job of planning a curriculum, we can achieve our objectives only by means of a series of individual courses. As I understand the topic, however, we are not so much concerned now with courses as with sequences of non-technical courses that might be fitted into the engineering curriculum, and particularly with a comparison between these and technical sequences.

Yet that comparison is not possible until we decide at least the fields of study that ought to be included. But even this preliminary decision is difficult—much more difficult than it was, say, twenty years ago. The first problem we think of, naturally, is how we can put additional subjects into our crowded four-year curricula. If we are to judge by the number of hours given to humanistic-social studies in present curricula, the answer apparently is that we cannot include more; and even in the integrated program recommended by the Committee on Aims and Scope, with technical subjects pruned and bleeding, there is not time enough for as many non-technical courses as nearly everyone would like

* Presented at the 49th Annual Meeting, S. P. E. E. (Instructional Methods), University of Michigan, June 23–27, 1941.

to include. Added to this difficulty, however, is the complication caused by the high school, where the program has been so radically changed that we can no longer expect our entering students to have thorough preparation in the specific subjects that we once took for granted. A generation ago we could be reasonably certain that freshmen had, for example, a course or two in history and in the fundamentals of English usage, but now we cannot be. Moreover, when the transcripts list these courses, we do not know what they contained or what the students learned. I understand, to be sure, that I could include mathematics, physics, and chemistry, but those subjects are outside the scope of our discussion. Naturally, I mention this situation here not as a criticism of the high school, but as an important factor with which we must reckon in building our curricula. It means that if we want students to have sound knowledge of even the fundamentals of a subject, we must provide it in college, and thus add to the burden of an overloaded curriculum.

With these difficulties in mind, our choice of subjects is restricted to those that ought to be in any curriculum and that can be fitted into a revised four-year program. What these subjects ought to be, I certainly do not know, but I propose three: English, history, and economics. I know that I am less open to criticism for what I include than for what I omit, such as the fine arts, modern languages, psychology, sociology, and philosophy. I should like to include all of them, but since I am offering a practicable rather than an ideal list, I omit these only because they seem to be less important to an engineering student. On the other hand, every college graduate ought to be able to express himself adequately and to have some knowledge of the scope and aim of literature so that he can read intelligently and profitably; he should have competent knowledge of our past and a sense of historical perspective; and the engineering student particularly should understand what is known of economic law.

If these are appropriate subjects, then what about sequences of courses within each one and their comparison with those in the scientific-technological group? By "sequence" we mean, I think, both the chronological order of courses and their placement in the curriculum. Naturally, there are sequences in both groups of courses; but if we assume that "sequence" means, as the title assigned me seems to suggest, a chain of courses in which each link is indispensable to the others—as in the example of mathematics-physics-mechanics—then the non-technical group has only a few sequences. The scientific-technological group has many of them, as you know, though even here, we ought to remind ourselves, the required courses are sometimes more desirable than indispensable.

In mechanical engineering, for instance, the "design" sequence provides in part for statics, dynamics, strength of materials, and advanced design. Between the last two, I am told, kinetics is desirable, and is generally required; but a student can take advanced design without it. Furthermore, in electrical engineering, a student needs alternating currents and mechanics in order to take electrical machines. In addition, he ought to have a course in electric and magnetic circuits, but he can get along without it. And then there are many independent courses stuck in here and there, such as chemistry, surveying, and machine shop for most students; elements of electrical engineering for mechanicals; and power plants and power applications for electricals.

Where chains of courses exist in the non-technical group, they are usually in the same subject and they differ from those in the other group chiefly in their length, consisting generally of no more than two links. In English composition, for example, a student cannot successfully take any advanced course, such as technical writing, preparation of reports, or business correspondence, without a basic course in language and composition; that is, he cannot do so unless the instructor in the advanced course ignores these fundamentals or scales down his course to include them, or unless the student gets them elsewhere. After he has had a thorough basic course, however, he should be able to get along in any advanced course regardless of sequence. In economics the situation is similar. Before he takes such courses as those dealing exclusively with money and banking and labor problems, he must have a basic course in economics. But here again, after he has acquired the fundamental concepts provided by the basic course, he should be able to take the others in any sequence. To be sure, we know that students can sometimes get through these advanced courses without the prerequisites, provided they acquire the basic knowledge as they go along—just as they can take, for example, alternating currents without statics, or mechanics without physics, but we know also that all of these courses move too rapidly for any but the most brilliant of such students to come out successfully. Moreover, we know that their understanding is not likely to be so thorough as it ought to be. For these reasons, we may say that courses in the foregoing sequences are indispensable.

But a point we ought to remember, I think, is that a sequence is no less valid because it is not a chain of indispensable courses. It may be only a series of courses, but a series determined by two important factors: the maturity and experience of the student and the better preparation of the student for each succeeding course. These factors govern not only the selection of courses, but also their order and their placement, both of which must be decided in build-

ing a curriculum. Why, for example, is the course in Industrial Organization, or its equivalent, usually placed in the senior year if not because the student should take it when he has as much age and experience as possible? In addition, he might get more out of the course if he had the broad background provided by a basic course in economics. Catalogs, to be sure, show that he apparently does not need this earlier course in order to succeed in the later one, and so if he were required to have it, he would be following not an indispensable but a desirable sequence.

Now, the non-technical group has many sequences of this kind. Even these, however, are not well enough established to be so generally accepted as mathematics-physics-mechanics, nor as algebra-trigonometry-analytic geometry-calculus, but whatever the disagreement may be, the aim is always to provide for each succeeding course a background of facts, concepts, skills, and perspective, and to place a course where the student most needs it and where it will do him the most good. A sequence in English composition serves as an example. The beginning course, I think, should be in the first year, not only because it is a foundation for other composition courses, but because self-expression is necessary in all other courses. Some say that the course should be deferred until the student realizes the need of it; but a majority of teachers agree that, inasmuch as most students come to college without thorough training in English language and composition, they ought to get it as soon as possible. On the other hand, a genuine course in technical writing should come in the junior or senior year, when there is a chance that the student's experience has given him something to write about. The same is true of a course in the preparation of reports, provided it goes beyond the writing of routine laboratory reports. Other sequences I can merely mention without much comment. In literature, the placement of courses is less important than their order. A student majoring in this subject cannot get the full benefit of advanced courses dealing with a single author, a type, or a period unless he has first had the background of survey courses in English and American literature and in English and American history. For engineering students, however, these courses are less important, because advanced courses for them are generally less specialized; but inasmuch as most of these students have read less widely than majors, they profit much from an introductory course dealing with the purpose and method and terminology of literature—a course, in short, that teaches them how to read intelligently and profitably. In history, a student cannot fully understand American history, which everyone ought to have, without an earlier survey of modern European history; and without these two courses or the one directly in line with later

study, he will always be hazy around the edges of any course dealing with a period or a country. Outside of history, these survey courses provide invaluable background for any serious study of literature, economics, and sociology.

Other sequences could be mentioned, but these should be enough to illustrate what is meant by a desirable sequence and to show its importance. Obviously, I am not saying that students without preliminary courses cannot pass later courses. I know that they do pass them. What I am saying is that they are greatly handicapped and, more important, that without great diligence on their part they emerge with only a vague smattering instead of a sound understanding—the same sound understanding aimed at and hoped for and worked for in the scientific-technological group.

In conclusion, I should like to present a sequence of courses in each chosen subject, giving the order, placement, and number of hours, though I do so only to provide a focus for discussion—or a target for attack. All of the hours, which are in parentheses after each course, are quarter hours.

Freshman	Sophomore	Junior	Senior
First-Year English (9)	Public Speaking (2)	Technical Writing (2)	Report Writing (2) or Business Correspondence (2) or Public Speaking (2)
	Introduction to Literature (2)		Masterpieces of Literature (2) (2) (2) or Novel (2) or Poetry (2) or Drama (2) or Shakespeare (2)
	Modern European History (9)	United States History (6)	
		Economics (6)	Money and Banking (2) and Labor Problems (2) and Industrial Organization (2)

A brief interpretation of some of these recommendations is necessary. Technical Writing would not be required of students with a high average in first-year English; but for it, they would substitute a second advanced course in literature. The advanced courses in literature and economics are merely suggestions; any others may be substituted for these or added to the list. Masterpieces of Literature is recommended as a three-quarter course, arranged so that a student may take any one quarter or all three.

United States' history is recommended as a year's course, as are also first-year English, Modern European History, and Economics.

The total number of hours for these courses is 46; but not all of these are additions to the curriculum. From these we can substract 15 hours, the usual number now given to similar courses, and also 10 hours generally allowed for electives. Thus we have left over 21 hours to be fitted somehow into our revised curriculum. How they can be, I do not know. But if they cannot be, then two questions arise: Is this amount of humanistic-social study too much or is the four-year course inadequate? The answers I leave for you to give.

MINIMUM ACCEPTABLE ACHIEVEMENT IN MECHANICS *

By GLEN N. COX

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The topic to be discussed shall be interpreted to include both the material to be covered and the degree of mastery which should be expected of the students. We shall understand the term mechanics to mean the applied mechanics, such as is presented in the texts by Seely and Ensign and others. It shall consist of the three parts: statics, kinetics and dynamics. It will be assumed that the student has completed his mathematics courses through the differential calculus prior to registration in statics, and will have credit in the course in integral calculus prior to registration in kinetics and dynamics. With this preliminary preparation, it will be assumed that the student possesses the tools needed for the analysis of the various problems which will be encountered.

Considerable time has been devoted to a study of the proper content of these courses, and to the study of other related subjects by various committees of the S. P. E. E. Certain of the findings of these committees will be reviewed. In 1916, E. R. Maurer † presented a progress report on the preparation of a syllabus on the subject of dynamics. In the discussion of this report, it was brought out that the chief difficulty was occasioned by a lack of coördination of the work of the physics and mechanics teachers. The lack of coördination was most felt in the matter of units in such an equation as

$$F = \frac{W}{g} a.$$

It was the expressed opinion that the student would be confused to a lesser extent if F and W were expressed only by the pound where the pound was the unit of force. These would be the only units which the vast majority of the students would ever have occasion to use and it only confused them to consider other units at that time.

At a later meeting, ‡ the main objectives in teaching mechanics

* Presented at the 49th Annual Meeting, S. P. E. E. (Mechanics), University of Michigan, June 23–27, 1941.

† *Proc. S. P. E. E.*, V. 24, pp. 194–7, 1916.

‡ *Proc. S. P. E. E.*, V. 27, pp. 327–33, 1919.

were considered. These objectives were summarized under the three headings: I. Objectives of Knowledge, II. Objectives of Habit, and III. Objectives of Attitude. To accomplish the goal set in this paper, it would be the duty of the instructor to give the student a thorough training in fundamental facts and principles which would enable the student to recognize the mechanical principles and the mathematical treatment which would be appropriate for the simple problems. It would also be the duty of the instructor to train the student in intellectual integrity, the use of good English, the ability to choose an economical method of study and such qualities as punctuality, ability to complete an assignment, to be numerically accurate and to be able to present the completed work in good form. Then there would be the need for the development of the purely personal attitudes of interest, coöperation, leadership, self-confidence and ability to recognize a duty.

You will notice that with the new personnel on the committee, the emphasis has changed from the syllabus to the responsibility of the instructor in building habits and character.

The matter of correlation again came up and was reported by O. H. Basquin,* Chairman of the Mechanics Committee. Prof. Basquin met Prof. Stewart, Chairman of the Committee on Physics, at Iowa City, and they concluded that the work was correlated if each instructor understood the aim of the other. The main difficulty for correlation was a lack of a *desire* on the part of *both* instructors. They found that it would be very difficult to force correlation where the desire was lacking since it then became necessary to work between two deans who, in turn, would probably be disinterested. The only avenue then remaining open would be to work through the president of the institution, which would indeed create an awkward situation.

Following the Mechanics School which was held in Madison, Wisconsin, during the summer of 1927, a report concerning the essentials in the mechanics course was written by Professor Maurer and others. This report was published by the Society in Bulletin No. 14 but the writer was unable to obtain a copy of this study. However, summaries of a portion of it were furnished by Professors E. R. Dawley, Kansas State College, and W. B. Johns, Jr., Georgia School of Technology. Since this portion of the report dealt with the minimum material which should be included in the mechanics course and since copies of the report seem to be no longer available, I feel free to quote from it. The following represents the concensus of the opinion of the engineers and the teachers of mechanics who attended the school:

* *Proc. S. P. E. E.*, V. 28, pp. 309–15, 1920.

There was unanimous agreement that certain sections (of the subject matter as covered in one of the standard texts) should be omitted, over eighty per cent of those replying to the request agreeing that the following were not among the essentials:

Stresses in flexible cords.
Journal and pivot friction.
Graphical and experimental methods of finding centroids and centers of gravity.
Products of inertia and the connected topics.
Coriolis' law.
Pendulums other than the simple pendulum.
The gyroscope.
Governors.

A majority of the replies in addition to the above, crossed out from the minimum essentials the following topics:

Graphical methods of analysis of concurrent and parallel forces in space.
Couples in space.
Non-concurrent, non-parallel forces in space.
Screw friction, belt friction and rolling resistance.
Motion of projectile.
All unusual components of acceleration.
Instantaneous center.
One method of analysis of kinetics of translating bodies.
One method of analysis of kinetics of rotating bodies.
Center of percussion.
Special applications such as hoop tension in flywheels.
Simple pendulum.
Balancing.
Loss of energy in friction in special bearings.
Dynamometers.
Applications of the principles of impulse and momentum to any special types of motion of rigid bodies.
Impact.

These items total eight pages more than one-third the pages of the text used. Accepting the opinion of the majority, the committee begs to present the following as those portions of analytical mechanics which may fairly be taken as the minimum requirements:

I. Fundamental conceptions, definitions, and principles such as are given in practically all texts in the introduction and opening chapter.
II. The resultants of co-planar force systems and the equilibrium of co-planar force systems by both analytical and graphical methods.
III. The application of II to the determination of stresses in common trusses and cranes (graphical analysis of stresses should be omitted if courses in graphical statics are given).

IV. Friction, coefficient of friction, angle of friction, laws of friction, with illustrative problems practically confined to bodies on horizontal or inclined plane and the wedge.

V. Moments of volume, mass, area and line, and centers of gravity, both by the method of calculus and the method of composition.

VI. Moment of inertia of areas and of solids both by the method of the calculus and the method of composition.

VII. Rectilinear, curvilinear and rotational motions of a particle omitting the specialized applications such as the pendulum, the projectile, etc.

VIII. Newton's laws of motion and their mathematical expression; rectilinear, curvilinear and rotational motions of solid bodies by one method only, omitting special applications to pendulums, governors, balancing and the gyroscope.

IX. Work, energy and power; omitting special applications to losses in bearings, and to use of special dynamometers.

X. The principles of impulse and momentum and their application to the analysis of motion of a body in common cases omitting impact and applications to gyroscope.

It must not be thought that these items include all that should be presented or taught to the class, but that which should be regarded as the minimum that should be demanded from the student in a course in analytical mechanics whether the course is presented in fifty-one class hours or in one hundred ten class hours.

The 1928 report * of the Committee on Mechanics set forth the results of a questionnaire for determining the division of quiz, test and examination questions between (*a*) definitions, (*b*) discussion, (*c*) derivation of formulæ and (*d*) solution of problems. This questionnaire served to show the proficiency which was expected in the various categories by the instructors. The use of definitions averaged 5 per cent, discussion 2 per cent, derivations 18 per cent and the solution of problems 75 per cent. In this same report, it was the concensus of opinion that there was no place in mechanics for the true-false type of test.

The reports in the *Proceedings* for the other years were not directly related to the topic which is now being considered.

Our ideas of the minimum essential material which should be presented to our students has not changed to any great extent since the preparation of Bulletin No. 14. There now seems to be a feeling that some time should be devoted to maximum and minimum moments of inertia, products of inertia, vibrations and balancing. Soon, there will even be a general demand for a treatment of the method of dimensions since it has obtained such great usage in the field of experimental engineering during the past decade. With these exceptions, the basic topics which are covered in most of our better schools have become very well standardized. There are

* *Proc. S. P. E. E.*, V. 36, pp. 338–9, 1928.

variations in the different schools, but the variation merely reflects the background of the instructors and the relative strength of the department in the particular school.

The real important difference is not so much in the material covered as in the manner of presentation and in the degree of proficiency required of the students. The real value of the course does not depend so much upon the inclusion, or exclusion, of a few topics in the course as it does upon the instructor's ability to get the student to really work.

So much for the minimum essential material that should be included. We will now consider the minimum proficiency which we have a right to expect. It is the opinion of the majority of us that a knowledge of mechanics can only be demonstrated by the student's ability to analyze the facts for a particular set of conditions and to arrive at a proper solution of the problem. We are not interested in the student's ability to memorize definitions or to be able to reproduce the derivations which appear in the text. These accomplishments fail to enable the student to analyze problems and are of little value in professional life.

The student should be able to interpret the given conditions and to transfer these conditions into a free-body diagram. From this point, he must be able to proceed in an orderly fashion to an accurate solution of the problem. The instructor must teach him to use the standard mathematical processes such as differentiation and integration whenever these offer the convenient and efficient method of solution.

The required degree of mastery is relative and varies from time to time with all instructors. However, every effort should be made not to pass any student who is unable to make a correct theoretical analysis of the problems coming within the scope of the minimum essentials as listed in Bulletin No. 14. Arithmetical errors will be made by all persons from time to time and these should draw a lesser penalty. However, a large number of mathematical errors are inexcusable. Students who consistently make many errors of this type should not receive a passing grade. Students who have the ability to analyze the problems in the aforementioned topics are very well equipped to go into more advanced engineering work and to solve the normal problems encountered in the profession.

In conclusion, let us go on record as opposing all special, or abbreviated, courses for any of the groups labeled engineers, if for no other reason than because a large percentage of the engineering graduates practice in fields other than that pursued in college. Since the facts given in mechanics are fundamental in nature, we must make every effort to maintain the high standards with which the mechanics teachers are credited.

TRAINING OF MATHEMATICIANS*

By RICHARD STEVENS BURINGTON

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This subject—The Training of Mathematicians—was selected because I feel certain that in the years to come there will be a growing need and a widening field for highly trained mathematicians of a type now *rare*, and in great demand, a type for which an adequate training program must be devised and developed, for no complete and comprehensive educational program for the training of such mathematicians exists today.

In view of this situation, it seems to me that those administrators and mathematicians who are responsible for the policies and actions of our graduate schools, should give a very considerable amount of thought as to the types of mathematicians they are producing, would like to produce, and should produce.

Speaking generally, I think that those universities and colleges which have been making a business of training mathematicians have been doing a very good job indeed, particularly when viewed in terms of the type of product they have strived to produce.

However, I have noticed that in some respects many mathematicians have been playing the part of isolationists in that they have been insulating themselves as far as possible from the results, efforts, and problems of their friends in the engineering, physical, and biological sciences. On the other hand, I have noticed that many engineers and scientists are playing a similar role in their relations with mathematicians and their many problems. Now by no means is this true of all individuals in these various fields, but since it is true of many of them I should consider these observations as indicative of a serious state of affairs, one requiring immediate corrective steps.

For certain purposes and under certain circumstances, and in the case of certain individuals, I have no doubt that such an attitude has been and will continue to be quite healthy, as indeed the tremendous growth in the mathematical sciences so indicates. But on the whole, this isolationist policy, this policy of mathematics solely for mathematicians, of mathematics solely for the love of mathematics, of mathematics pure and uncontaminated by applica-

* Retiring address as Chairman, Mathematics Division, S. P. E. E., delivered at the 49th annual meeting, University of Michigan, June 23–27, 1941.

tions, has led mathematicians as a group into a serious (though curable) form of anemia.

As one evidence of this unhealthy condition may I point out that the mathematics group has acquired the reputation among many competent and important men in other fields of being unable to put their mathematics to work. While I am quick to object to this harsh criticism, particularly in view of the remarkable contributions made by some of our mathematicians to progress in the physical fields, I am nevertheless convinced that such complaints are warranted. The trouble lies in the fact that while we have been training certain types of mathematicians, we have been neglecting the training of *mathematicians for service.** In some respects, we are far advanced in our program toward the training of mathematicians, but in other respects we are woefully behind.

In order to illustrate some of the things we are overlooking, I shall consider some leading goals in the training of medical students. It is well known that no first class medical school would think of training physicians solely for teaching positions, solely for medical research, solely for public health service, and so on. They attempt to train all of their students to be, first of all, practical physicians. They teach them to find, if humanly possible, an immediate mode of treating critical cases. They teach them to find an immediate answer to their problem when it is at all possible. But while they train them in emergency methods, they also teach them methods of searching diagnosis and complete treatment to be used when time and facilities will permit. They also attempt to teach them preventative methods, methods which tend to be most economical and devoid of distress on the part of the patients. They try to anticipate possible epidemics, and they encourage the ones who go into research work to develop and improve methods for the prevention, relief, and cure of such epidemic diseases. They direct their research workers to the many problems of human suffering which as yet, man has been unable to control.

Let me say at once that while in most cases mathematics is not directly concerned with the relief of human suffering, and that, moreover, while the subject matter studied by medical students in almost totally different from that undertaken by students of mathematics, yet nevertheless, abstractly, the results aimed at in the training of mathematicians should not be fundamentally different from those of the physicians. Thus, we might ask: Are we training mathematicians (i) solely for teaching positions, (ii) solely for pure mathematical research, (iii) solely for research positions in

* The recent organization of a graduate school in Advanced Mechanics at Brown University is a notable step in correcting this neglect.

industry, (iv) solely for routine work in industry, (v) solely for work in the Army or Navy?

For the most part, a good job is being done in training mathematicians for college and university teaching positions, and for research work in pure mathematics. Training men for these two types constitute the principal business of the majority of our graduate schools of mathematics, as constituted today. This is all very good indeed. But *what about the training of mathematicians for service in industry?* Practically nothing has been done. Something should and will be done.

Are we training mathematicians to use good common sense, to be practical as well as theoretical? Are we teaching them to use their mathematical knowledge to solve problems in other branches of science and engineering, to make rapid estimates or approximations to solutions when the precise solution would require a great deal of time and energy? Are we teaching them "diagnosis," that is, are we teaching them of the art of translating into mathematical language physical problems, which are only too often loosely stated if stated at all; of the art of somehow effecting exact and approximate solutions to the mathematical problems so obtained; and are we training them in the skills needed to interpret the mathematical solutions so obtained in the physical language of the original problem? I wonder. In general, our graduate schools of mathematics have not been training mathematicians along these lines. They have not been training *mathematicians for service.*

Are the majority of problems selected for thesis work in our schools of mathematics purely mathematical, their possible physical motivations (if any) being so far removed from the actual thesis that neither the directing professor nor the student knows anything but the pure mathematical setting of the problem? Or, do many of the mathematical theses being assigned have close relationships with physical problems, the students being thoroughly familiar in each case with the setting and connections between the physical and the mathematical problems under consideration? The later type of thesis problem is definitely in the minority. Should this be? No, not if we are training mathematicians for service.

A casual glance at the history of mathematics shows the great impetus the famous physical problems of many years ago gave to mathematical research in general. Should we not again turn most seriously to the physical universe for fresh stimulus to mathematical investigation? The so-called old classical field of physics is a veritable mine for such problems, the solutions for many of which industry would find immediate uses.

The many physical and mathematical problems relating to defense are so complex in all their phases that the War Preparedness Committee of the Mathematical Societies, of which I am a member, has felt that it is time and past time for a revival of applied mathematics. Marston Morse, Chairman of the Committee, in a report * to the Mathematical Societies at Dartmouth called for "a renaissance in applied mathematics." This is most encouraging for it indicates a halt in the isolationist attitude of which I spoke. In this connection I should also call your attention to the recent address † of W. L. Hart, Chairman of the Committee on Education for Service, delivered at the Baton Rouge meeting of the National Council for Teachers of mathematics. The type of training which I propose in this paper is thoroughly consistent with the point of view of Professors Morse and Hart, and the product of such a program should be equally useful whether in peace or war times.

At the present time most of the young men receiving their Doctorates in Mathematics seek and find positions as teachers in our various colleges and universities, few go into industry. This results in a form of inbreeding, and a styling of mathematics, which in time is apt to be deadening. Should not then, more young mathematicians seek industrial contacts?

The trend toward extreme specialization within the field of mathematics seems thoroughly ill advised. A broad background and training in the various principal branches of mathematics should be required of all doctorate candidates, irrespective of their subfield of specialization. This is particularly important in the training of mathematicians for service. Such a requirement of broad training is met in various degrees by the several schools of mathematics, but I urge that moves to strengthen and encourage broader background training should be made at once.

A careful survey of the present situation, taking into account the inevitable booms and depressions to be expected from time to time, indicates that there is now and that there will be in the future continuing demand for the following types of mathematicians: (*a*) teachers, (*b*) research mathematicians (pure), (*c*) statisticians, (*d*) actuaries, (*e*) consultants and service mathematicians for industry, (*f*) research mathematicians for industry.

As I have stated before, training programs for types (*a*), (*b*), (*c*), and (*d*) are now amply provided for in a number of excellent institutions. But, adequate programs for *training mathematicians for service to industry*, types (*e*) and (*f*), must be provided.

* See address, delivered before the National Council of Teachers of Mathematics at Atlantic City, February 21, 1941.

† Mathematics in the Defense Program, M. Morse and W. L. Hart, *American Mathematical Monthly*, Vol. 48, pp. 293–302.

It is well known that there is at present an acute shortage of physicists, and good applied mathematicians. In a recent report * T. C. Fry of the Bell Telephone Laboratories estimated that there are employed about one hundred fifty professional mathematicians in the industries of this country. Dr. Fry makes a strong plea for the creation of a center for the training of mathematical consultants for industry. The demand for such mathematicians exceeds the supply.

But this program of training mathematicians for service is not merely a war time measure, it is also a long range peace time program. A thorough study of the situation, noting the rapid increase in the use of precise machines; the increasing cost of necessary research, development, and production; the tremendous increase in the use of mathematical methods in the literature of almost every field; and taking cognizance of the inevitable competition in business, which will follow this war, both intranational and international, leads one to the conclusion that more theory, and better methods must and will be used, and that necessarily an even greater use of mathematics will then be made by private and public industry.

The field for service mathematicians will grow, particularly when more properly trained mathematicians can be placed in industry, and when a larger number of industries find that such mathematicians are really "worth their salt." That a number of most excellent men do exist today, and that they are of great value to their companies is quickly noted when one studies the personnel and operations of certain of our great industries.

It is too much to expect any ordinary engineer or scientific worker to have the wide acquaintance with mathematics which occasionally may be required of him. Properly trained mathematical consultants with an understanding of the problems and language of the engineer and scientist, when working together with trained technical men, should be able in a great many cases to reduce the cost of research, development, and production.

A program for the proper training of any type of professional mathematician is essentially one for the graduate school. Provision should be made to train all the types of mathematicians listed above, pure mathematicians as well as applied mathematicians. I think it would be a good thing if all types could be trained in the same institution, so that the students in the various fields could freely mix and discuss their varied problems and interests.

My interest in this paper is primarily concerned with the train-

* Research—A National Resource, II, pp. 268–289, National Research Council.

ing of mathematicians for service to industry and I shall hereafter concern myself entirely therewith.

The development of an educational program for the training of mathematicians for service to industry will require a great deal of study, time, and energy. Many things will have to be tried and experimented with before an adequate program will emerge in a mature and successful form.

It is obvious that only mature students with marked ability and an intense interest in both the mathematical and the physical sciences should be admitted for study. The undergraduate curriculum preparation recommended as prerequisite should be essentially that required of an engineering physicist or electrical engineer, and preferably should include courses in organic and physical chemistry, heat power engineering, strength of materials, dynamics, and four years of mathematics.

The graduate curriculum for service mathematicians should lead successively to the Master's degree; the degree of Mathematician, or Applied Mathematician; and finally, to the Ph.D. degree.

In general, one year's full time graduate study should be required for the Master's degree, and at least one additional year for the degree of Mathematician. In general three to four years graduate study should be required for the Ph.D. degree.

In addition, at least six months actual experience as a mathematician in industrial work should be made a requirement for the degree of Mathematician, or for the Ph.D. degree. I feel quite sure that schools of mathematics can arrange for ample coöperation on the part of industry in furthering such a program.

In general, the courses taken by the students working for the degrees of Mathematician and Ph.D. should be about fifty per cent in pure mathematics, thirty per cent in applied mathematics, and twenty per cent in the engineering and physical sciences.

The courses in pure mathematics should be given with the highest standards of rigor now generally in force in our better graduate schools. The training in pure mathematics should be very broad. It should include comprehensive courses in the fields of analysis, geometry, and algebra. Work in statistics, probability, graphical and numerical methods, when not included in the undergraduate preparation, should be insisted upon.

The courses in applied mathematics should be given with strong emphasis on the physical side of the material given but with greater care in reasoning than is currently taken by those in the physical sciences who teach such courses. Comprehensive courses in elasticity, electricity and magnetism, analytical dynamics, hydro- and aero-dynamics, statistical mechanics, and quantum mechanics should

be included. Practical astronomy with some navigation should be added if not included in the undergraduate preparation. A number of courses in modern physics and advanced engineering topics should be considered as desirable.

A penetrating introduction to all of the above topics should be urged upon all degree students, irrespective of the branch of applied mathematics the individual selects for his thesis and specialty.

A thesis should be required for each degree, and the subject of the thesis should be directly concerned with the problem arising in a physical setting, and requiring mathematical methods of more than ordinary procedures. In the case of the doctorate, the thesis problem should be one requiring a definite research contribution.

May I emphasize the great importance to be attached to the inclusion of six or more months of actual experience in industry, away from school. A year spent in industry before completing the Ph.D. degree would aid the student immeasurably in digesting course material, and in obtaining a firmer hold and maturity in mathematical and industrial methods.

A natural reaction to the list of requirements suggested above would seem to indicate that such a curriculum would require eight or more years of work. However, I am convinced that simpler, yet penetrating approaches to the subject matter of this proposed curriculum can be developed, approaches that will be superior to the treatments now available, thus permitting the digestion of such a comprehensive program without undue strain on the student.

A natural criticism of this program is that it is too vast and expensive in view of the relatively small number of mathematicians who need to be trained to fill the demand. However, the mathematical requirements which advanced students of engineering, chemistry, and physics should have has been growing rapidly, and will continue to grow indefinitely. The existence of the program for the training of mathematicians for service will automatically furnish a far better list of mathematics courses for such students. Therefore, such a program in a few institutions does not seem impractical.

In conclusion may I urge graduate schools of engineering and mathematics to enrich their programs of study in order to train more rounded groups of mathematicians, who will be able materially to aid engineering and scientific institutions, and industries, in meeting their responsibilities. Unquestionably, the existence of such a program would not only reflect itself in the improvement in the training of large graduate groups in physics and engineering, but also in the improvement of undergraduate students, many of whom are sent out each year into industry before completing their training.

THERMODYNAMICS FOR GRADUATE STUDENTS OF MECHANICAL ENGINEERING*

By JOSEPH H. KEENAN

Professor of Mechanical Engineering, Massachusetts Institute of Technology

Nothing would be more fatal to the profession of mechanical engineering than to define its activities solely in terms of things that mechanical engineers have always done. The mechanical engineer must not only *operate* in the fields of power, refrigeration, air conditioning, and the processing of materials, but he must be prepared to *advance* in them. Technological progress knows no professional boundaries. Progress in the automotive engine goes with the employment of charts of properties of the fuel-air system in its original state and in its most stable state. Many mechanical engineers would say that here the problem becomes one for the chemical engineer rather than for the mechanical engineer. It is clear, however, that if the mechanical engineer will not cross the boundary with progress, then progress will cross it without him.

Again, if the mechanical engineer is too respectful of boundaries, he may be left entirely outside a new and important industry. I am thinking in particular of the petroleum industry, which, in the days that saw the development of the reciprocating steam locomotive, was an infant industry. Today it is one of our major industries. Mechanical engineers have been employed in it, but there is a tendency among its managers to relegate to the mechanical engineer those problems for which the method of solution is pretty well known. The problem for which a method must be found are reserved for the chemical engineer, the chemist or the physicist. There is grave danger that other industries will acquire the same state of mind.

It is considerations such as these that should govern a selection of material for a graduate course in thermodynamics. They point to a course which is broad of base and rigorous in structure, rather than one which is merely a more exacting consideration of some specialties like the steam turbine or the refrigerating machine. In fact they point to a course in the science of thermodynamics rather than in engineering thermodynamics.

* Presented at the 49th Annual Meeting, S. P. E. E. (Mechanical), University of Michigan, June 23–27, 1941.

It is a truism that the engineering techniques of tomorrow evolve from the scientific generalizations of today. The aeronautical engineer of today follows in the footsteps of the mathematician of a generation ago. The techniques of tomorrow in any one field of engineering will be more numerous than those of today, and they will therefore use the resources of science more fully. To our fathers applied mechanics was the beam theory. To us the beam theory is but one of a multitude of techniques in the fields of statics and dynamics that we call applied mechanics.

We may prophesy, therefore, with great confidence that the most useful study for the man who must do the research and the design of tomorrow will be fundamental and general. In our particular field it will be a course in the science of thermodynamics that lays down definitions and principles and proceeds through corollaries to enough applications to inculcate the subject and to reveal its resources.

As engineers we need not apologize for teaching a course in science. Doubtless many of our scientific colleagues could do the task in an acceptable way, but they start under great handicaps. The physicist, for example, is interested in thermodynamics primarily as a handmaiden to statistical mechanics. He suffers too frequently from what I call the Saturday-afternoon state of mind. A colleague of mine once said that a physicist thumbs through a textbook on thermodynamics, and finding no unfamiliar mathematical developments decides to delay mastering thermodynamics until he has a free Saturday afternoon. When called upon to teach thermodynamics he is too prone to spend two or three weeks striding in the seven-league boots of mathematics from the elements to the farthest extremities of the subject and then to relax in the green pastures of statistical mechanics. Among physicists, however, there are some brilliant exceptions to this rule who have made notable contributions to the exposition of thermodynamics.

The chemist is more willing to consider thermodynamics as a subject worthy of attention in its own right. Indeed, the physical chemist has often drunk from the purest springs of thermodynamics while engineers were imbibing muddied waters. From the standpoint of the engineer, however, the chemist is inclined to idealize processes overmuch. For example, one textbook on physical chemistry describes work as a property of the environment of a system. That is, work flows from a system when weights in the environment *are* raised in level. This point of view could only be taken by one not engaged in the production of work. The engineer produces work for home and industry, and only a minor portion of it results in the rise of weights. At no place except at an imaginary boundary immediately surrounding the system can the

engineer identify work. As he considers places more and more remote, more and more of the work has vanished in the course of irreversible processes. The chemist deals with a hypothetical environment, the engineer with a real one. The chemist idealizes out of his problem many of the puzzling features that the engineer must face.

Nevertheless, I should rather entrust a student to a physical chemist for his instruction in thermodynamics than to many heat engineers. For myself, I gladly acknowledge that I have learned more thermodynamics from physical chemists than from any other professional group.

To teach a graduate course in thermodynamics we must be prepared to teach science. Fortunately, we shall not be asked to pioneer in science because it appears from the experience of seventy years that the extent of thermodynamics was adequately explored by Willard Gibbs. We may select certain fields within that extent that might well be developed to special uses, but we need look for no new fields. If exploratory work is to be done we may safely leave it to the scientist.

In a graduate course we must draw the most punctilious distinction between definition and principle. Therefore, we must start at the very beginning of our subject. We must state the First Law without the aid of undefined concepts. If the term *energy* is used it must be previously defined in such a way that a number can be obtained to represent its magnitude for any state of the system under discussion. Nor should it be assumed that some other science provides an adequate definition, since energy in its most general sense is a thermodynamic concept. Great emphasis must be laid on the definitions of work and heat and on the concept of a property. The internal energy should be proved to be a property as a corollary to the First Law, or the statement that it *is* a property should constitute the First Law. In any event, it must not be married to the molecule to make it an honest property.

How much description will be necessary to familiarize the student with processes and characteristics of typical systems will depend upon his undergraduate experience. He should be familiar with the characteristics of the vapor phase, the liquid phase, and, at least, one solid phase of the pure substance. The perfect gas is unimportant at this stage and serves to introduce more mathematical machinery than is necessary to our purpose.

In fact, to illustrate the First and Second Laws, I prefer homely and familiar systems and processes, including familiar chemical reactions. For example, the student may be asked to indicate the magnitude relative to zero (+, 0, or —) of the heat, the work, and the variation in internal energy for a system consist-

ing of the air in a tire and a connected tire pump when the piston of the pump is forced inward, or a system consisting of a mixture of gasoline and air in a rigid, non-conducting envelope when a minute spark causes an explosion.

The questions raised in the application of the First Law by changes in relative motion of parts of the system and by gravitational effects should be answered. Fortunately, Gibbs has suggested entirely satisfactory means of dealing with these.

Problems in flow are more likely to receive adequate attention from a teacher who is an engineer than from one who is a scientist, because the engineer can seldom idealize his problems so as to eliminate flow. The graduate student—and perhaps the undergraduate student—should not limit his attention to steady flow, but should consider the more general problem of what might be called the *open system*.

It is safe to prophesy that the engineer who is prepared for engineering of the future will not consider the Second Law too difficult for comprehension. Our teachers of thermodynamics have too often been guilty of bad pedagogy in emphasizing the difficulty of stating the Second Law, and in discussing the mysterious and ghostly nature of entropy.

The Second Law is no more difficult to state than the First Law. I believe I could defend this statement by offering from published texts as many misstatements of the First Law as of the Second. Moreover, Carnot's thesis, which is generally considered to embrace the Second Law, antedates by some years the enunciation of the First Law.

That ghostly quantity entropy is no stranger than its counterpart internal energy. It is true that internal energy is conserved under conditions of isolation and that under the same conditions the entropy increases toward a maximum. But before the advent of thermodynamics scientists found a property of systems which seemed to trend always toward a minimum. This property proved later to be the internal energy and the statement of the trend came to be known as the principle of virtual work. The internal energy is a Phœnix rising from its ashes; the entropy, a ghost growing fat.

For the graduate student the Second Law must be stated clearly and unequivocally, and it must be put to use immediately by deriving corollaries of the law. The concept of reversibility must be clearly defined, and once again resort should be had to many homely and familiar processes, including chemical reactions.

From the statement of the Second Law should follow the definition of the thermodynamic scale of temperature; the proof that entropy is a property, the proof of the Clausius inequality and of

the principle of the increase of entropy. The Clausius inequality has been too much neglected by engineers. In the classroom it can serve a useful purpose in that it emphasizes the distinction between entropy and the heat-temperature quotient—a distinction that cannot be overemphasized. Moreover, it is the most direct path to the subjects of availability and equilibrium.

Thus far we have outlined material that *must* be included in our course. Beyond this we may list subjects which deserve consideration, but no one of which must be included. Let us discuss the merits of some.

No course in mechanical engineering is complete without at lease one year of work in chemistry. All arguments in favor of this practice are equally in favor of teaching the thermodynamics of chemistry. The application of the First Law to chemical reactions and to the process of solution is simple and can be taught in a few hours. This is sometimes given in a course in physical chemistry, but repetition will bring it into the thermodynamic structure at small expense in time. The partial properties that are so useful in processes involving solution might well be introduced at this point. The Second Law may be applied through the Clausius inequality to show the utility of the functions $(u\text{-}Ts)$ and $(h\text{-}Ts)$.

The chemical engineer already realizes, and the mechanical engineer must soon realize, that the preparation of tables of properties of substances cannot be left to a small group of experts. The number of substances employed in industry is increasing so rapidly that the orderly preparation of definitive tables cannot possibly keep pace. The engineer himself must step into the gap armed with a knowledge of the partial differential relations for the pure substance and some of the techniques by which they may be employed. It would seem proper, therefore, to include a discussion of the many relations that derive from the equation

$$du = Tds - pdv$$

and the methods they reveal for obtaining entropy, internal energy, enthalpy, etc. from the pressure-volume-temperature relation.

If the mechanical engineer is to contribute to the field of petroleum engineering, he must think in terms of mixtures and rectification of mixtures. This is an extensive and involved field, but a study could be made of the phase relations of binary mixtures and the processes of rectification of binary mixtures without making the course topheavy.

The fluid mechanics of the compressible fluid must engage the attention of men with training in thermodynamics if further progress is to be made. We can discuss reversible and irreversible flow

in ducts when variations in velocity distribution are unimportant. We can show the relative stability of supersonic flow and subsonic flow and we can analyze the pressure shock. These are important studies and lead to formulations that have great utility. There remains the question of reversible and irreversible flow around obstacles in a stream. The first step must be the analysis of a potential flow in a compressible fluid. So far the attack has been almost purely by the methods of fluid mechanics. Perhaps it will always be so, and thermodynamics will in this case prove unfruitful. We must await the development of new and better trained engineers before we shall know.

There is no better way to exploit the possibilities of the Second Law in industrial processes than through the subject of *availability*. It is true that an availability analysis is of less immediate utility than an energy analysis. An energy analysis usually tells how much of something is necessary to accomplish a given purpose. An availability analysis tells how good or how bad is each part of a process as compared with other parts. It permits us to compare quantitatively such different processes as evaporation in a boiler on the one hand and expansion in a turbine on the other, or combustion of a fuel-air mixture on the one hand and throttling through an exhaust valve on the other. These are the signposts that guide the engineer who looks toward the future.

No one can know the resources of thermodynamics who has not studied thermodynamic equilibrium, because it is here that thermodynamics reaches its full stature. The study of equilibrium emphasizes the all-embracing nature of the First and Second Laws and shows how they provide the potentials by which we may recognize tendencies toward change and the criteria by which we may judge the relative stability of systems.

It is not only the heat engineer who will profit from a study of thermodynamic equilibrium. There is probably no better introduction to the theorems of equilibrium employed in mechanics than the treatment outlined by Gibbs in his paper on equilibrium of heterogeneous systems. The principle of virtual work appears as a restricted form of a criterion which follows directly from the principle of the increase of entropy. Thus we find that thermodynamics embraces a fundamental principle of mechanics as a special case of a more general principle. Stating it another way, the discovery of the Second Law was foreshadowed a century before in the discovery of a criterion of mechanical equilibrium. Moreover, the *possible variations* employed so effectively by Gibbs in 1875 were a generalization of the *virtual displacements* employed by Johann Bernoulli in 1717.

Before studying chemical equilibrium, the engineer should study Gibbs' treatment of the equilibrium of the pure substance. Perhaps because the work of Gibbs has been kept alive largely through the efforts of the physical chemist, the first two papers in the *Collected Works* have received less attention than they deserve. In the first we find the arrangement of lines of constant pressure, temperature, entropy, and volume about a point. It is easy to add lines of constant internal energy and enthalpy. These arrangements will serve as touchstones by which the validity of a development of the properties of a pure substance may be tested.

In the second paper we find the celebrated primitive and derived surfaces in the energy-volume-entropy space. Here we can *see* the relative stability of (for example) a van der Waals type of substance. We can see the distinctions between stable, metastable, unstable, and neutral equilibrium. Moreover, we find here in graphic form the availability of the pure substance.

Some attention might well be given to metastable states in view of the current interest in the subject and the unsolved problems that we face. We should discuss the degree of stability of the supersaturated vapor and the superheated liquid. We should derive the Kelvin-Helmholtz relation for unstable equilibrium between a vapor and drops of liquid and between a liquid and bubbles of vapor.

The engineer who is to contribute to the development of the internal-combustion engine, or of any process involving a chemical reaction, should be familiar with the thermodynamics of chemical equilibrium. Here again we may follow Gibbs, at least through the first fifteen pages of his great paper on the equilibrium of heterogeneous substances. We may demonstrate how this concept of a balance of active tendencies, which we employ in discussing mechanical equilibrium, may be carried over by means of the chemical potential into more complex systems involving mixing, solution, and chemical reaction. The equation of chemical equilibrium brings us to the equilibrium constant and leads naturally to the property *fugacity* which is already prominent in the literature of chemical engineering.

There are many other subjects of engineering interest in this work of Gibbs that are not too difficult for a good graduate student. We might list the phase rule, the effect of pressure on the vapor pressure of a liquid, the relation between osmotic pressure and vapor pressure, capillarity and the effects of a curved surface of discontinuity between phases, equilibrium in a gravitational field, the modification of the conditions of equilibrium by electromotive force.

But we are outlining a graduate course, not a lifetime of study. We have already listed sufficient material for more than a full year of vigorous work. Some of this material is already finding its way down into undergraduate courses. We can make room for it there by practicing more rigid economy (but not at the expense of rigor) in the exposition of the elements of the subject, and by substituting thermodynamics for overemphasized specialities in heat engineering. This, I am convinced, is the direction of progress. Moreover, it is the direction in which teachers of heat engineering must have the courage to proceed if mechanical engineers are to retain their place in the forefront of engineering progress.

THE FUNCTIONS OF PHYSICS COURSES IN THE ENGINEERING CURRICULA *

By EDGAR P. SLACK

Associate Professor of Physics, Polytechnic Institute of Brooklyn

The Department of Physics in an engineering school is, I take it, a service department for the engineering divisions, and our function is to serve. I looked that word up in the dictionary, and found that there are two synonyms for "serve": they are "minister" and "succor." Now, I have never noticed any of my colleagues going around burdened with an overload of piety; I don't think we are ministers, and so I guess that we are the suckers. It is our job to take the crude material as received, work it over as best we can, gradually eliminate the part that does not respond to treatment, and turn over to the engineering departments, as our output, a smaller group of men whom we have encouraged to master a few basic principles and whom we have tried to stimulate to think coherently.

Just what the Physics department can do, and what it ought to try to do, will probably be quite different in different schools. Each one has its own history and traditions, and its personnel have their individual ideas; and the demands upon the Physics department will vary accordingly. As servants, we ought to try always to do what the engineering departments want us to do, even if this means giving up some of our own pet ideas. Real coöperation among the departments will tend to create the same attitude in the students, and if it does, it will give them something more valuable after graduation than the material that we had to omit. To say nothing of ourselves: we spend a large part of our lives on the job, and we will have much more of the joy of living in an atmosphere of friendly coöperation.

But it is often difficult to learn what the engineering departments want us to do. Some of them will say that they suppose we are competent in our own line, and they will leave it up to us. Others would have us stick solely to fundamental principles and leave out everything in the way of engineering applications. Still others would like to have us cover more and more ground, and so provide extra time for them to give advanced theoretical courses.

* Presented at the 49th Annual Meeting, S. P. E. E. (Physics), University of Michigan, June 23–27, 1941.

And sometimes I have the feeling that each of the engineering departments, down deep in their hearts (if they have any), wishes that we would cover the fundamentals in each of the other branches and leave their own students for them to start with from scratch.

Of course, the Physics people have some ideas in these matters. We believe that a thorough mastery of the fundamental principles of physics is of more value to the graduating student than the factual information which he might receive from a highly specialized engineering course. Many employers want to train their recruits in their own ways, and moreover many students study one branch of engineering and then find employment in another. If they have the fundamentals and have learned how to think, they will get along all right. It is perhaps the most common criticism leveled at our engineering curricula that they are not fundamental enough. This means that the highly specialized courses should be carefully pruned down, and more time made available for the stressing of fundamentals. The ordinary allotment for Physics, say from 10 to 15 semester-hours, is usually too short, especially when you consider the frictional drag of those students who are eventually eliminated.

As to what we ought to teach, I am only repeating what has often been said before when I state my own conviction that what we teach is less important than how we teach it. If we can stimulate the student to think for himself; to state his problem and analyze it; and then to chart his course and go through to a conclusion, we have done the job. How this can be done, I don't know any more than you do; it rests largely with the individual teacher. He must love his work above all else; he should, if possible, have a background of actual engineering practice; he must like his students; and he must keep on studying—something—all the time, to keep the student point of view. And if he was rather dumb as a student in his own college days, why so much the better. I need only mention what you already suspect: that the last item which I referred to is an outstanding qualification of the present speaker.

But to get back to the question of subject matter. I presume that the Physics department will teach Physics, and in most cases the usual subdivisions are probably as good as any: mechanics, fluids, heat, electricity, sound and light. The one that is taken up first should be allotted more time than the others, so that the instructor can take the student by the hand, so to speak, at the start. I think that each of these courses ought to extend just into the engineering course that is to follow it; mechanics ought to have just a little on simple structures; electricity should just get into Kirchhoff's laws for the electric circuit, and so on. Tying in

Physics with future engineering as well as with past experiences of the student is most desirable for the prospective engineer, as it gives a direct point to the physics courses and stimulates and holds the interest of the student.

Another job that the Physics department must undertake is to conduct a laboratory course, often the first one encountered by the student. What a place for him to learn Physics! Here he can verify his theories, learn to handle apparatus, and acquire those habits of carefulness and orderliness that will contribute so much to a controlled and well-ordered mind. A difficulty here which is probably experienced by many schools is to find laboratory instructors who will subscribe whole-heartedly to such principles as these, and who will regard their laboratory classes and report reviewing as vital matters in the education of the student and not merely as matters of perfunctory routine. Along with the laboratory work must come something on precision of measurements—always an extremely difficult subject for the beginner, and no wonder, since it seems to be a direct violation of what he has been taught in arithmetic ever since he multiplied two numbers together in the primary school. The plotting of curves is another new process which must also be squeezed in. There is a question in my mind on which I hope that there may be some discussion, as to what the Physics department ought to require in the way of laboratory reports, in view of the limited time available for the study of Physics. For some years, at the school where I work, we have been requiring the student to prepare what might be called a junior engineering report. It starts with a statement of the object of the experiment; then follow in considerable detail the theory, description of apparatus, and procedure; next come the data, calculations, and results; the report finally ends with conclusions. While there is undoubtedly some training value in the preparation of such a report by the student, there are some parts of it—the conclusions, for instance—for which he is insufficiently mature; and I have wondered whether we should not cut this way down, so that the student's report would consist only of calculations and results, including an estimate of precision, together with the answering of a few searching questions. Is it a proper function of the Physics department to try to teach report writing, or should we not stick to Physics?

I recommended earlier that highly specialized engineering courses be pruned down to allow more time for fundamentals. I should not neglect to recommend also that each of us so-called physics teachers take count of stock and see that we are really using the time available to the best advantage in the teaching of fundamentals. We all have some pet hobby which we tend to overemphasize. One teacher would enlarge on momentum and impulse

if everything else went by the board; still another can't get away from the subject of lens aberrations; my own form of lunacy is an over-fondness for units along with every number in a physical equation. No doubt these things all have their uses, but I think we should scrutinize them impersonally and make sure that they are kept in proper perspective in the picture.

Before closing, there is one more thought that I wish to express. Engineering is full of things that once were physical abstractions. We can all think of examples to bear out the old saying: The physics of today is the engineering of tomorrow. If I might venture to surmise what is likely to happen, it would not be unreasonable to suppose that atomic structure is destined to play a large part in the engineering of the future. I think that we in the Physics department ought to find time to include some of the elementary notions of this subject in our undergraduate courses.

NECROLOGY

LAWRENCE N. FIELD

Lawrence N. Field, professor of machine design in the department of mechanical engineering at Michigan State College, who died of a heart attack in Chicago, Saturday, October 24, 1941, was one of the most prominent educators in the state.

Professor Field's experience was extensive. After attending Michigan State College for a year he went to the University of Michigan where he obtained his degree as bachelor of mechanical engineering. In 1912 he worked in the experimental department of the Goodyear Tire and Rubber Company at Akron and later was with the Singer Manufacturing Company at South Bend, Ind., and the Buick Motor Company in Flint. In February, 1916, he came to Michigan State College as assistant professor of mechanical engineering and had been at the East Lansing institution ever since.

Professor Field was a member of the American Society of Mechanical Engineers, being honorary chairman of the student branch at the college, and a member of the council of the Detroit section of A. S. M. E. He was also affiliated with the Lansing Engineers' Club, Tau Beta Pi, of which he had been treasurer for several years, Sigma Xi, Phi Lambda Tau, Pi Kappa Phi, the Michigan State College athletic council, and the Society for the Promotion of Engineering Education. He was in charge of United States engineering defense training courses in drafting and tool design at the college.

HARRY SLOAN HOWER

Harry Sloan Hower, born July 24, 1877, Parker, Pa., died October 10, 1941. He received his B.S. from Case School of Applied Science in 1899; took graduate work at the University of Berlin, 1903–05. Professor Hower taught physics at the Conneaut, Ohio, High School, 1899–1900; instructor at Case 1900–06; at Carnegie Institute of Technology since 1906, Professor of Physics and head of the department since 1915. He had been a consulting physicist since 1915 for the Corning Glass Company. Professor Hower was designer of lenses for range lights for the Panama Canal Commission, United States Navy submarines, Army Searchlights and Norwegian merchant ships.

Professor Hower had been a member of this Society since 1914. He also belonged to American Physical Society, American Association for the Advancement of Science, American Optical Society, American Ceramic Society, Illuminating Engineering Society, English Society of Glass Technology, Pennsylvania Academy of Science; Sigma Xi, Tau Beta Pi and Theta Xi.

JOHN T. WALTHER

John T. Walther, Professor and Head of the Department of Electrical Engineering, University of Akron, died suddenly November 4, 1941.

Professor Walther graduated from the University of Michigan in 1909 with the degree of bachelor of science in electrical engineering. After graduation he worked at the Westinghouse E. & M. Company in Pittsburgh going to Akron in 1917. He was electrical engineer at the Firestone Tire & Rubber Company from 1917 to 1919 when to took over the task of laying out the new Firestone electrical substation. He directed planning and specifications of power lines, switchboard and other details of the station.

Professor Walther joined the staff at the University of Akron as instructor in 1920. He was a member of the American Institute of Electrical Engineers and of this Society since 1924.

DEVELOPMENT OF LIBRARIES THROUGH PURCHASE OF BOOKS

Carnegie Corporation of New York, on the recommendation of its advisory group on academic libraries, appropriated $55,800 on October 16, 1941, for development of libraries in technological colleges through purchase of books for general undergraduate reading. This appropriation is divided into 11 grants in behalf of the colleges named below.

Each grant is available one-third annually beginning October 1, 1941. The annual instalments will not be paid to the recipient college but will be held by the Corporation to meet bills for books purchased by the college through a centralized purchasing agency which has been set up by the Corporation in Ann Arbor, Mich. Through this agency substantial savings, chiefly from greater discounts, and probably more effective service as well may be had through pooling purchases desired by recipient colleges. It should be understood, however, that neither the Corporation nor the advisory group has any desire or purpose to control or influence the choice of titles. The details of this plan for centralization of purchases are in the hands of the Chairman of the group, Dr. W. W. Bishop, University of Michigan, Ann Arbor, Mich., who will be glad to give full information.

Case School of Applied Science, Cleveland, Ohio	$ 6,000
Colorado School of Mines, Golden, Colo.	6,000
Drexel Institute of Technology, Philadelphia, Pa.	4,800
Georgia School of Technology, Atlanta, Ga.	6,000
Michigan School of Mining and Technology, Houghton, Mich.	4,500
Montana School of Mines, Butte, Mont.	3,000
Rensselaer Polytechnic Institute, Troy, N. Y.	6,000
South Dakota State School of Mines, Rapid City, S. D.	3,000
Stevens Institute of Technology, Hoboken, N. J.	6,000
Tennessee Polytechnic Institute, Cookeville, Tenn.	4,500
Texas Technological Institute, Lubbock, Texas	6,000
	$55,800

ROBERT M. LESTER,
Secretary.

ENGINEERS' COUNCIL FOR PROFESSIONAL DEVELOPMENT

A total of 461 engineering curricula at 129 colleges and universities in the continental United States have now been accredited by the Engineers' Council for Professional Development, through the inspection program of its committee on engineering schools. Provisional accrediting has been given 104 additional curricula. These figures were announced at the ninth annual meeting of the Engineers' Council for Professional Development, held October 30.

Committee reports on the Council's major activities featured the annual meeting, at which also officers were elected for 1941–42. R. E. Doherty, president of Carnegie Institute of Technology, Pittsburgh, Pa., was elected chairman for a second term; H. T. Woolson, executive engineer, Chrysler Corporation, was reëlected vice-chairman. H. H. Henline, national secretary, American Institute of Electrical Engineers, New York, N. Y., was elected E. C. P. D. Secretary, and A. B. Parsons, secretary, American Institute of Mining and Metallurgical Engineers, New York, N. Y., Assistant Secretary.

Newly elected committee chairmen are: D. B. Prentice, president, Rose Polytechnic Institute, Terre Haute, Ind., committee on engineering schools; E. S. Lee, engineer, general engineering laboratory, General Electric Company, Schenectady, N. Y., committee on professional training; G. Ross Henninger, editor, American Institute of Electrical Engineers, New York, N. Y., committee on information. The following committee chairmen were reëlected for the coming year: R. L. Sackett, dean emeritus of engineering, Pennsylvania State College, New York, N. Y., committee on student selection and guidance; C. F. Scott, professor emeritus of electrical engineering, Yale University, New Haven, Conn., committee on professional recognition; D. C. Jackson, professor emeritus of electrical engineering, Massachusetts Institute of Technology, Cambridge, Mass., committee on engineering ethics.

The short engineering courses provided by the Engineering Defense Training program should not receive credit toward degrees, the committee on engineering schools recommended, pointing out this would interfere with the primary objective of the courses. The defense program has highlighted the lack in the United States of facilities for technical education of a grade between the engineering college and the vocational school, the committee noted, announc-

ing the appointment of a subcommittee to work with the Society for the Promotion of Engineering Education to develop a program for accrediting technical institutes. Attention was called to the increase in engineering schools operated for private profit and granting engineering degrees under existing state laws. A year's study in such schools, in the opinion of the committee, is not equivalent to a year in an accredited curriculum. The committee also recommended that the Engineers' Council for Professional Development continue its policy of limiting the variety of engineering curricula accredited, accrediting specialized curricula only as options under accepted general curricula.

Recognition that the defense program and the probable employment problems following the emergency affect the relationship of younger engineers to their professional societies was indicated in recommendations of the Council's committee on professional training, urging immediate consideration of these problems. This committee also recommended that the national engineering societies hold clinics for professional guidance.

A study of the bases of selection of engineering students to be made jointly by the Society for the Promotion of Engineering Education and the Engineers' Council for Professional Development was recommended by the latter's committee on student selection and guidance, which continues also to encourage engineers to carry on guidance work among high-school students in their communities. A new E. C. P. D. guidance booklet, "Engineering as a Career," authorized for immediate publication, is expected to be available soon to take the place of the booklet "Engineering—A Career, A Culture," which is out of print.

During the past year, the Engineers' Council for Professional Development took over the sponsorship of a joint committee on engineering ethics, representing several national engineering societies. Reporting preliminary work in the drafting of a canon of engineering ethics, the committee recommended that a statement on the influence of ethics on the basis of a profession be prepared by the Council's committee on professional recognition. The latter committee reported continued study on the problems related to professional recognition.

REPORT ON THE AIRCRAFT STRUCTURES CONFERENCE

By M. S. KETCHUM

Chairman, Committee on Structural Engineering, Civil Engineering Division

A conference on Aircraft Structures was held at New York University on September 5 and 6, 1941. This was a part of the work of the Committee on Structural Engineering of the Civil Engineering Division. The purpose of the conference was to orient structural engineering teachers in the field of aircraft structures. It was the opinion of the committee that many teachers would be called upon to teach courses in aircraft analysis and design this year and that a discussion of the problems involved would be of considerable benefit to them.

Papers were presented by both teachers and engineers in the practice of aircraft structures.

On the morning of Friday, September 5th, F. K. Teichmann, New York University, discussed "The History and Development of Aircraft Structures." This paper showed the trend of airplane construction from tubular framework to shell construction. In a paper "Codes and Specifications for Aircraft Structural Design" by Burdell L. Springer of the Civil Aeronautics Administration, the requirements of the government for aircraft structures were presented.

At noon on Friday, a luncheon was held at the Commons of New York University presided over by H. E. Wessman, New York University. Hardy Cross, Yale University, clearly defined some of the policies that the teaching profession should take in training structural engineers for aircraft design.

In the afternoon, the sessions were devoted to more technical problems. A most interesting paper was "Details for Aircraft Construction—Materials and Methods" presented by Guy A. Luburg, Brewster Aeronautical Corporation, Long Island City, New York. Educational problems were discussed in "Course Content for Aircraft Structures" by N. S. Hoff, Polytechnic Institute of Brooklyn. The application of methods of aircraft structural analysis to other problems was given in a paper "Application of Aircraft Structural Theory to Civil Engineering Structures" by M. S. Ketchum, Case School of Applied Science. A study of the background of aircraft

design was presented in "Aerodynamic Bases of Structural Analysis" by Alexander Klemin, New York University.

On Saturday morning a most interesting and instructive talk was given on "Methods for the Analysis and Design of Shell-Type Structures" by Lieut.-Commander Joseph A. Wise, U. S. Naval Academy. The final paper of the session was given by Oscar Erlandsen on "The Place of Indeterminate Structures in Aircraft Structural Analysis." Mr. Erlandsen particularly emphasized the complexity of some of the problems and the importance of studying the deflections of aircraft structures. The group was particularly impressed by the amount of time available for the analysis of structural details and the precision with which the failure of some of the parts of an airplane could be predicted.

The Committee on Structural Engineering felt that this conference served a useful function and meetings of similar types should be encouraged in the future.

COLLEGE NOTES

University of Illinois.—A few months ago Professor A. N. Talbot resigned the chairmanship of the A. R. E. A. Committee on Stresses in Railroad Track. This committee started an investigation of stresses in railroad track in 1914, and the investigation is still in progress. Professor Talbot has been in charge of this investigation since its beginning. The reports of this investigation constitute the best body of information about stresses in railroad track available anywhere. The very first progress report was hailed as a classic in engineering research. It is as fine an example as can be found of an investigation in which mathematical analysis, laboratory tests, field tests, and the accumulated experience of practical engineers have been blended into a coherent whole.

In honor of Professor Talbot's leadership in this investigation the American Railway Engineering Association on October 21, 1941, unveiled a tablet citing Professor Talbot's achievements in this work, and presented the tablet to the University of Illinois to be placed in the Arthur Newell Talbot Laboratory of Materials Testing.

Preceding the formal unveiling of the tablet, a luncheon was given by the A. R. E. A. to invited guests at which Mr. Louis Yager, Chairman of the special A. R. E. A. tablet committee presided. The formal unveiling of the tablet took place in the College of Engineering of the University of Illinois at 4 o'clock in the afternoon. The ceremony was attended by a large number of students and members of the faculty, by some fifty members of the A. R. E. A. and other guests. Mr. W. S. Lacher, Secretary of the A. R. E. A. was the presiding officer, Dean M. L. Enger accepted the tablet for the University, and Mr. F. L. C. Bond, President of the A. R. E. A. and Vice-President and General Manager of the Canadian National Railways delivered the principal address. The response by Professor Talbot closed the exercises.

This tablet is a well-deserved tribute to a great piece of engineering research and to Professor Talbot, the chief of the test party which carried out the work.

The following men are now members of the engineering staff of **Villanova College:**

Kenneth J. Moser, Assistant Professor of Mechanical Engineering, received his M.E. from Stevens Institute of Technology in 1928 and his M.S. in 1941.

Harold J. LeTart, Instructor in Mechanical Engineering, received his Bachelor of Mechanical Engineering from Michigan State College in 1937 and since has been engaged in design work.

Harry Blumenfeld, Instructor in Chemical Engineering, graduated from the Polytechnic Institute of Brooklyn in 1940 with the Bachelor of Chemical Engineering degree and received his M.S. in Chemical Engineering from the University of Florida in 1941.

Clemson College.—Enrollment this fall was limited to the capacity of the barracks and a considerable list of applicants had to be denied after the 2300 places had been filled. Scholarship standards are being improved both by raising the grade point ratio required for graduation and by stricter rules for promotion.

Numerous changes have taken place in the engineering teaching staff. A. B. Credle, Assistant Professor of Electrical Engineering, resigned to accept a similar position at Cornell University. J. H. Sams, Associate Professor of Mechanical Engineering, is on leave, having been called into service as a Major in the Air Corps, on technical work at Wright Field. C. P. Philpot, Assistant Professor of Forge and Foundry, resigned to become Assistant Director in the Wm. W. Moore School of Technology at Memphis, Tenn. C. M. Gaylord, Instructor in Civil Engineering, resigned to take an Instructorship in Mechanics at N. C. State College. J. B. Down, Instructor in Mechanical Engineering, resigned to take a similar position in Rice Institute. L. R. Ambrose, Instructor in Shop, is on leave for Army service, serving as a 2nd Lieutenant in Ordnance doing instructional work at Aberdeen. E. J. Freeman has been advanced from Associate Professor to Professor of Industrial Engineering in charge of Metals Shops. H. R. Martin, B.S. Kansas State, and M.S. Iowa State, in Mechanical Engineering, has been appointed Instructor in Mechanical Engineering. Mr. Martin has been teaching at Iowa State the past three years. I. A. Trively, B.S. and M.S. in Civil Engineering, University of Nebraska, has been made Instructor in Civil Engineering. Mr. Trively has been teaching in the Civil Engineering Department at the University of Nebraska. A. D. Lewis, B.S. University of Tennessee, is a new Instructor in Mechanical Engineering. Mr. Lewis has had experience in electrical construction and in the Mechanical Engineering department of the Aluminum Company of America. H. H. Wiss, B.Arch. and M.Arch. Rensselaer Polytechnic Institute, has been added to the staff of Architecture as an Instructor. Mr. Wiss has had varied experience as a designer and teacher. C. W. Carter, B.S. Clemson '32, has been added to the Drawing Department Staff as Instructor. Mr. Carter has been teaching in National Defense work. J. H. Couch, B.S. Clemson '41, has been made Instructor in Metals Shops.

Under construction on the campus are a new concrete stadium and a new water purification and pumping plant. Hospital facilities were augmented by a hundred bed addition in the upper floors of a rebuilt textile building. The Physics Department has occupied the lower floors of the same building, with well lighted and conveniently arranged class rooms and laboratories. An alumni building to furnish reception quarters for visitors and offices and other facilities for the Physical Education Department was completed and occupied during the past year.

SECTIONS AND BRANCHES

After a period of inactivity of about two years, the **Maine Branch** of the Society has been revived.

On Friday, October 3, 1941, a meeting was held at which the following officers were elected:

Clarence E. Bennett—*Chairman.*
Walter J. Creamer—*Vice-Chairman.*
Ralph A. Sawyer—*Secretary.*

The Fall Meeting of the **New England Section** of the Society for the Promotion of Engineering Education was held at The Thayer School of Civil Engineering, Dartmouth College, Hanover, N. H., on Saturday, October 18, 1941. The total registration was 271 members and guests. A printed list of those present is attached as a supplement to these minutes.

The following conferences were held from 10 A.M. to 12:15 P.M.

Chemical Engineering—Attendance 22. Chairman: C. P. Baker, Northeastern University.

Place of Management in the Chemical Engineering Curriculum. A. S. Knowles, Northeastern University

The Teaching of Unit Operations.

Relative Importance of the Various Unit Operations. C. E. Reed, M. I. T.

Function of the Unit Operations Laboratory. H. E. Graves, W. P. I.

Textbooks, Lectures, and Problems as Aids to Teaching Unit Operations. T. S. Crawford, R. I. S. C.

Civil Engineering—Attendance 26. Chairman: A. D. Taylor, Norwich University.

What Is an Experiment in Hydraulics? Grant Robley, Yale University.

Hydraulic Model Tests. L. J. Hooper, W. P. I.

Drawing, Design and Shop—Attendance 21. Chairman: W. E. Farnham, Tufts College.

Relation of Shop Experience to Design. M. Lawrence Price, W. P. I.

Defense Training Courses. Group Discussion led by the Chairman.

Economics—Attendance 12. Chairman: A. J. Schwieger, W. P. I.

Fitting Economics into the Thinking of the Undergraduate Engineer. D. S. Tucker, M. I. T., and W. C. Beatty, Brown University.

Electrical Engineering—Attendance 42. Chairman: E. A. Walker, University of Connecticut.

Graduate Programs for Electrical Engineering Departments of Limited Registration. T. H. Morgan, W. P. I.

New Curriculum in Electrical Engineering at Lehigh University. L. V. Bewley.

Engineering School Libraries—Attendance 14.

Meeting of Engineering School Librarians for the purpose of discussing plans for coöperation and organization.

English and Engineering Education—Attendance 20. Chairman: W. F. Scamman, University of Maine.

Desirability of a Balanced Program in English for Engineering Students. H. R. Bartlett, M. I. T.

Teaching of English as a Professional Tool—The First Requisite. R. L. Blanchard, Brown University.

Mathematics and Physics—Attendance 24. Chairman: C. F. Muckenhoupt, Northeastern University.

What Does the Student Dislike in our Method of Teaching. B. H. Brown, Dartmouth College.

Place of Physics in the Engineering Curriculum. F. W. Pote, Tufts College.

Mechanical Engineering—Attendance 42. Chairman: A. L. Townsend, M. I. T.

Should a Thesis be Required of Seniors? F. J. Daasch, University of Vermont.

Laboratory and Class-Room Instruction in Fluid Mechanics. K. G. Merriam, W. P. I.

The minutes of the University of Connecticut meeting and the financial report for the year ending October 16, 1941, were approved.

From 1:30 to 3:00 the Engineering School Librarians met and were addressed by Professor D. C. Jackson on the subject "The Library in Engineering Education: How Can Its Usefulness Be Developed?" The attendance was 23.

Chairman Morgan presided at a General Session. The subject "An Engineer's View of Engineering Education," David C. Prince, President, American Institute of Electrical Engineers; Manager, Commercial Engineering Department, General Electric Company, was presented as well as "The Civil Service Commission and National Defense" which was presented by E. J. Stocking of the United States Civil Service Commission. Attendance 123.

The annual dinner was held at 6:30 P.M. at the Hanover Inn. Attendance 197. The Secretary announced that there were 271 in attendance (199 members and guests and 72 ladies). The Secretary pointed out that the Franklin Technical Institute had an attendance of 7 out of 3 members or 233 per cent, that Dartmouth had 6 present with a membership of 5 or 120 per cent and that Boston College had its one member present or 100 per cent.

H. P. Burden, Chairman of the Nominating Committee, presented its report, and Dean Frank W. Garran was nominated for chairman for the ensuing year and C. E. Tucker for secretary. The nominations were seconded, Professor Morgan put the nomination to vote and the secretary was authorized to cast one ballot for the nominees in spite of his name being on the ballot.

The following resolutions were presented and unanimously accepted by the section.

"The members of the New England Section of the Society for the Promotion of Engineering Education in annual meeting assembled at Hanover, New Hampshire, October 18, 1941, wish to express to Dartmouth College and the Thayer School of Civil Engineering their sincere appreciation of the hospitality and the friendly coöperation which have made for the complete success of this meeting.

"We also wish to express our appreciation to the officers of the Section, its Chairman, Professor Theodore H. Morgan, its Secretary, Professor Carlton E. Tucker, and the committees which have so efficiently planned and carried out the program for this meeting.

"We wish to thank those who have participated in the conferences and also the special speakers of the afternoon and evening sessions.

"To the ladies of the local committee who as hostesses have made the stay of the ladies of our party most pleasant, we extend our sincere thanks."

Resolutions Committee,
ARTHUR D. BUTTERFIELD,
L. W. HITCHCOCK,
G. H. MACCULLOUGH.

Gordon Gliddon of Dartmouth gave a very interesting address on the organization and work of the Dartmouth Eye Institute.

FINANCIAL REPORT

October 16, 1941

Receipts

Cash in bank Oct. 14, 1940	$11.70
Cash 188 lunches and 199 dinners at 15 cts.	58.05
Contribution from two members outside New England	2.00
Interest	.38
	$72.13

Expenditures

Printing	$24.25
Postage	15.97
Telephone	1.70
Mimeograph	3.47
Cash in Bank Oct. 16, 1941	26.74
	$72.13

Outstanding bills to be paid for from the receipts of the meeting:

Printing	$26.55
Postage	1.82
Mimeograph	.65
	$29.02

November 3, 1941

Receipts

Cash in bank Oct. 16, 1941	$26.74
Cash from Dartmouth meeting	51.75
	$78.49

Expenditures

Printing	$26.55
Postage	2.02
Mimeograph	1.30
Cash in bank November 3, 1941	48.62
	$78.49

CARLTON E. TUCKER, *Secretary*,
New England Section, S. P. E. E.

The **North-Midwest Section** of the Society held its seventh annual meeting at Madison on October 10 and 11. Alfred H. White, national president, was principal speaker at the banquet on Friday night. There were 260 members and wives at the banquet. Total registration was 163, of whom 111 were from other than the host institution.

The new officers for the coming year are as follows:

Chairman—L. O. Stewart, Iowa State College.
Vice-chairman—W. J. Hebard, Marquette University.
Secretary-Treasurer—F. E. Lightburn, Iowa State College.
Board member—G. F. Tracy, University of Wisconsin.
L. A. Rose, Michigan College of M. & T.
R. W. French, University of Minnesota.
J. W. Howe, University of Iowa.

The eighth annual meeting will be held at Iowa State College, probably early in October, 1942. The date has not been fixed exactly.

L. F. VAN HAGAN, *Secretary*.

BOOK REVIEWS

Elements of Electrical Engineering. ARTHUR L. COOK. John Wiley & Sons, Inc. 622 pages. Price $4.

This is the fourth edition of the well-known test, "Elements of Electrical Engineering." A review of this new edition shows that it has been completely rewritten with a number of minor changes made in the text material in order to bring it up-to-date with present electrical engineering practices. The general outline and method of treating the subject matter is the same as in previous editions. The greatest number of changes has been made in the chapter on Light and Illumination and the chapter on Electronic Devices.

The text material of the book is divided into four parts: Part 1, Electric and Magnetic Circuits; Part 2, Direct-Current Machinery; Part 3, Alternating Currents; and Part 4, Alternating-Current Machinery. Each of these parts contain approximately ten chapters, each chapter covering one particular devision of the material. This treatment of the subject matter makes the book very adaptable for a complete course in electrical circuits and machinery or, by using certain parts of it, an abbreviated course for elementary work as an introduction to the real electrical engineering work. The clear, simple style of exposition and the thorough explanations makes the book especially good for elementary courses in electrical engineering such as are given to sophomores in many engineering schools.

A goodly number of splendid problems are included at the end of each chapter. These problems have all been changed from those used in former editions. In all the book contains some 593 problems.

The tables given at the end of the text have been revised to bring them up-to-date with the latest revision of the National Electric Code.

C. A. ANDERSON

General Chemistry. Fourth Edition. HARRY N. HOLMES. The MacMillan Company, 1941. 720 pages. Price $3.75.

The fourth edition of this standard text is a definitely improved book. The organization of material on the nonmetals and the principles has undergone little change. It has been brought up-to-date with a greater use of modern concepts of valence and ioniza-

tion and the inclusion of newer industrial processes. In the section on Organic Chemistry more complete treatment has been given to petroleum refining and synthetic rubber.

It is in the section on metals that the greatest improvement has been made. The entire section has undergone a drastic rearrangement. Instead of studying the metals as members of a periodic family with the encyclopedic enumeration of occurrence, metallurgy, physical and chemical properties and uses of each metal, which usually was most successful in completely confusing the student, Holmes has considered the metals as a group. First, the occurrence and metallurgy of all the metals are considered, then properties and uses, a chapter on alloys, and finally a study of the compounds of the metals. This arrangement gives a coherence that the other lacked.

A new chapter on "Strategic Raw Materials" is timely and of general interest. The exercises are complete and the references brought up-to-date. A decrease in the number of chapter outlines is to be deplored. The fourth edition will make a fine text for the general college student.

R. E. McCLURE

Insulation of Electrical Apparatus. DOUGLAS F. MINER. McGraw-Hill Book Co., Inc. $5.00.

This book is an interest-provoking, general treatment of an extremely important subject. Heretofore many treatises for the specialist have been available, but there was no treatment giving a general picture of the subject for the beginner and non-specialist. Dr. Miner has presented a digest of facts, theory, and commercial practice in very readable language and almost conversational style. The book should find wide use in insulation and design courses, and should be a valued addition to the library of the practicing engineer.

The introduction discusses the importance of insulation and the approach to the study of insulation problems. The vulnerability of insulation, itself a prime necessity in all electrical apparatus, is responsible for most failures of equipment. Insulation design is not a problem to be solved in precise terms by the application of a single comprehensive theory; rather it involves many separate, distinct factors, the effects of which can be treated only approximately. The author points out that "wide margins of safety, which might be termed 'factors of ignorance'" must be employed. Moreover, in the present state of knowledge the insulation of each class of apparatus is a separate problem to be studied by itself. Multitudinous and varied are the materials available to the designer; many of the new plastics have proved especially valuable as insulators.

In the first two chapters fundamental dielectric phenomena and various theories of dielectric behavior are briefly reviewed. Chapter III discusses quantitatively individual factors affecting dielectric behavior: duration of the electrical stress, temperature, moisture content, frequency, wave form, repetition of the electrical stress, rate of voltage rise, thickness, mechanical stress, and geometry of electrodes. Chapter IV gives a comprehensive listing of commercial insulating materials, solid, liquid and gaseous, and discusses each briefly, pointing out the advantages and disadvantages that lead to its use or rejection in particular applications. Precautions to be observed in using each material are also given. Of particular help is the discussion of the many trademarked products, especially in conjunction with Appendix C, a Plastics Directory. Numerical data for various materials are given in the tables and curves of Appendix A.

The next twelve chapters, comprising half of the book, take up the application of insulation to specific classes of apparatus, transformers and reactors, circuit breakers, transmission line insulators, lightning arrestors, capacitors, heating appliances, lamps and tubes, meters, instruments and relays. Altogether a very broad field of commercial practice is covered with commendable clarity. The author treats each class of apparatus broadly, giving in some instances principles of operation and showing how insulation design is related to factors other than electrical stress, such as conduction of heat, mechanical support, ease of fabrication and assembly, repair, and so forth. The role of insulation as a material of construction is emphasized and it is pointed out that economic factors and mechanical properties are often more important than dielectric properties in determining the insulation used.

The final two chapters comprise a discussion of insulation testing as to equipment, technique, and interpretation of data. Specifications of the A. S. T. M. and A. I. E. E. are included.

Appendix B discusses the relation of temperature limits of insulation to the rating of electrical apparatus.

Throughout the book figures and curves are used extensively, in all more than 300, and numerous references to original articles are given.

B. R. TEARE, JR.

Blue Print Reading and Sketching. H. R. THAYER, M.S., Assistant Professor of Engineering Drawing. 141 pages, McGraw-Hill Book Company, Inc. $2.00.

This volume of "Blue Print Reading and Sketching" is one of an industrial series of texts prepared under the direction of the

Division of Engineering Extension, The Pennsylvania State College.

Since many of the computations involved throughout the book involve areas, volumes, orders, bills, costs, and estimates, the course will refresh the students' knowledge of elementary mathematics. Modern shop terminology is used consistently. This fact gives the book a delightful industrial flavor.

The book has been divided into twenty-four lessons, which include a wide range of information over the various fields of engineering in which drawings, specifications, and bills of material are presented. A generous supply of questions and problems for student use are provided with each lesson.

A sample each of drawing, tracing, and blue printing is included as pages of the book. Four sample blue prints are tucked in a pocket inside the back cover. These include a complete drawing of an automobile, an airplane, a general plan of a mill building, and a drawing showing detailed drawings of certain parts of a machine assembly and a bill of material for the job.

The book is very well written and I think a creditable addition to the literature in this field. It will certainly be a useful tool to students who are trying to learn drawing and blue print reading.

R. C. GORHAM

Mathematics. JOHN W. BRENEMAN, C.E. McGraw-Hill Book Co. 1941. 207 Pages. 119 Figures. $1.75.

Mechanics. JOHN W. BRENEMAN, C.E. McGraw-Hill Book Co. 1941. 139 Pages. 178 Figures. $1.50.

Strength of Materials. JOHN W. BRENEMAN, C.E. McGraw-Hill Book Co. 1941. 144 Pages. 138 Figures. $1.50.

These three books are the first volumes of the Pennsylvania State College industrial series and were prepared under the direction of the Division of Engineering Extension of that college. They are short and concise reviews of the subjects to be used in the many defense courses for the practical shop man. The volume on mathematics, for example, covers briefly the subjects of arithmetic, fractions, algebra including simultaneous and quadratic equations, plane geometry and trigonometry. A fine group of tables is included and a great deal of information on their use. Problems are numerous and practical as they are typical shop problems taken from actual situations in industry.

The same description applies equally well to the other two books. They should find an immediate and wide use in the practical training courses throughout the country.

Peele's "Mining Engineers' Handbook," Third Edition, 2 volumes, written by a staff of forty-six specialists, under the editorship

of Robert Peele, with the collaboration of John A. Church, published by John Wiley & Sons, Inc., New York, as volumes VI and VII of the Wiley Engineering Handbooks series, uniform in size with Eshbach's "Engineering Fundamentals," Kent's "Mechanical Engineers' Handbook," and Pender's "Electrical Engineers' Handbook," about 5½ x 8⅜" and 1½ to 1¾" thick per volume. Price $15.

Peele quickly became the standard mining engineers' handbook after the first edition was published in 1918. It has been very highly regarded and widely used by practicing mining engineers and in the mining schools ever since. The original text was extensively revised and the second edition issued in 1927. The authors' preface for the new edition lists some 18 sections of the 45 which make up the 2 volumes as having been radically revised, and mentions minor changes made in many other parts of the book.

The above mentioned more important revisions in the text and illustrations for this new edition were made in the sections dealing with "Excavation," "Explosives," "Shaft Sinking," "Prospecting, Development and Exploitation," "Hoisting Plant, etc.," "Mine Ventilation," "Compressed Air Practice," "Electric Power," "Wages and Welfare," "Mining Laws," "Aerial Tramways and Cableways," "Underground Mechanical Loading, Conveying, and Handling," "Selling, Purchasing and Treatment of Ores," "Gold Amalgamation and Cyaniding," "Preparation and Coking of Bituminous Coal," "Power and Power Machinery." Thirteen of the sections above referred to had been almost entirely rewritten or greatly altered in the preparation of the Second Edition.

The practical use of the new edition will be facilitated in that the sections are numbered as in the earlier edition, that is, Section one is still "Mineralogy," Section two "Geology and Mineral Deposits," Section eight was "Shaft-Sinking in Soft, Water-Bearing Soils," is now "Shaft-Sinking in Unstable and Waterbearing Ground" and so on. The new Section 10A, of 42 pages on "Geophysical Prospecting," replaces the 16¼ pages of data in articles three and four of Section 10. Section 44 is "Petroleum Production Methods" and the "Engineers' Tables" formerly 44 is now 45. Where the revision has not been too extensive, the numbering of the subdivisions of the "Sections" called "Articles" generally follows that of the earlier edition.

The high professional standing of the 62 contributors inspires a well deserved confidence that this handbook will continue to be the leading one in mining engineering. The larger size of page and the more open setting of type in some places make the new edition easier to read and use. In general, an excellent piece of work has been done in this revision, not only in the major places

listed above, but in many other subjects in the text of frequent importance to the mining engineer. Another improvement is that the books, when put open on a table for reference, expose the leaves more flatly.

The extensive changes make it very difficult to estimate the amount of increase in reference text contained, but several counts from roughly similar pages, page counting, etc., indicate an increase about equivalent to 200 or more pages of the new edition, although the actual number of pages in the handbook is about the same as or slightly less than in the second edition.

S. L. GOODALE

The Engineering Profession. HOOVER AND FISH. Stanford University Press. 441 pp. $5.00.

"The Engineering Profession" is the most comprehensive book of recent years on engineering, its content, education, method and objectives. Eighty-two (82) engineers contributed data and counsel but individual contributions are not disclosed (or are merged in the whole). Fourteen (14) chapters, 42 tables, 29 diagrams and a *good index* are features.

"Who is an Engineer" and "What is Engineering" are disclosed in the first two chapters. Various definitions are given later but "Engineering is the professional and systematic application of science to the efficient utilization of natural resources to produce wealth" is selected and analyzed.

Chapter 3 is a good discussion of "Fields and Functions of Engineering."

Chapter 4 describing Civil Engineering and 5 which is devoted to Mining Engineering, and their main subdivisons, are the most comprehensive and well balanced descriptions of fields. The first occupies 34 pages and the second is equally well treated in 29. As Dean Emeritus Hoover was head of instruction in Mining Engineering and Professor Fish, now emeritus, was head of the department of Civil Engineering, it is to be expected that these chapters should be well written.

At the end of each chapter devoted to major divisions, there are three unique features of interest. They are lists of problems for research, lists of engineer societies related to each field and a "Selected Bibliography" of books, bulletins and journals. Typical curricula in the various divisions and specialties are outlined. Historical mile posts in the development of each major field are listed.

The treatment of "Remuneration" varies for beginners and may represent relative demands in the west but in the east the pay of beginners in the various fields is more nearly equal, other conditions being the same.

The chapter on *Mechanical Engineering,* of 40 pages, begins with "Mechanical engineer's contribution toward the production of a piece of tongue-and-groove flooring." It describes the tools, transportation of ore, transformation into machines used in logging, and the finishing of wood products. Then comes "Conversion of an invention into washing machines." The sequence of functions and steps in design, development and production are well stated, but organization receives only scattered and inadequate treatment. The various types of apparatus designed, built or used by the mechanical engineer are listed but power generation receives only general treatment.

"Industrial Management" heads a list of administrative, operating and social problems needing research but there is very little discussion of the main subject which at the present time deserves a fair measure of emphasis. Problems of personnel and personality are slighted.

It is predicted that in power generation "a decrease in demand may be expected, as fuel burning plants will lag because of large hydroelectric projects being undertaken by the government." In sales, tool and shop processes, aero transportation research and management the outlook is considered promising while in some others it is not. The remuneration of beginners in mechanical engineering is rated relatively low despite the marked demand.

The chapter on Electrical engineers follows the same general pattern in the 19 pages devoted to it. The sub-headings are: Subfields of Electrical Engineering, The Electrical Engineer and His Job, Pathways to Professional Work in Electrical Engineering, Where the Electrical Engineer Spends His Time, Disadvantages and Hazards, Remuneration, Future Demands for Electrical Engineers, Accomplishments of Electrical Engineering, Problems for Research in Electrical Engineering, Professional Electrical Engineering Societies, Curricula in Electrical Engineering, Selected Bbliography.

Chemical, Agricultural, Architectural and *Acoustical* Engineering are treated in the 21 pages of chapter 8.

E. C. P. D. has accredited the following numbers of curricula in several fields:

Name of Curriculum	No. of Curricula Accredited
Chemical Engineering	39
Industrial Engineering	19
Options as part of other accredited curricula	9
Architectural Engineering	14
Options as part of other accredited curricula	2
Ceramic Engineering	3
Options as part of other accredited curricula	1
Acoustical Engineering	0

It seems reasonable from the above and from the large number of students enrolled in chemical engineering, that it should receive more than the eight pages devoted to it however good they may be, and it does squeeze in the essentials by outlines. If the same method were used in treating other divisions, the book could be much reduced in size.

Agricultural and *Architectural Engineering* receive very modest attention. One asks why Acoustical Engineering is dignified by a page when Aeronautical, Automotive and Industrial Engineering receives only mention as options of a major field, scattered discussion or none at all. There will be difference of opinion of the adequacy and proportion in the treatment of the different major fields of engineering.

Chapter 9, *The Method of Engineering,* is both historical and analytical embodying the deductive method as applied to computable problems and the inductive method as illustrated by modern research. Consistency of data, the degree of accuracy of observations and the corresponding probability of error in the result are considered. The problems are simple but illustrate the method. The analyses of choice, of evaluation and integration are good.

Chapter 10, *Application* of the *Engineering Method,* is illustrated by simple problems in geometry, structures, water supply and the Hetch Hecthy Water Supply for San Francisco to which latter 15 pages are devoted. All are civil engineering except the first.

Problems in engineering economy are absent although Professor Fish is the author of "Engineering Economics."

"Uncertainties in Engineering," chapter 11, include classes of errors, adjustment of observations in surveying, rational and empirical formulas, materials, factors of safety, the life of structures, population and demand, water storage, cost of construction, cost of operation and income. No problems.

"Vocational Guidance in Engineering" devotes proper space to the part that personal qualities play especially imagination, originality, industry, honesty, loyalty, dexterity, and physique. The various functions are described and how and where engineers find jobs.

"Education of the Engineer" includes the discussion of (1) general subjects, (2) general technical subjects and (3) special subjects, general and technical which are essential to some fields but not all. The author's philosophy of engineering is partly revealed in the conclusion of this, the 13th chapter.

"When engineering education includes in parallel fashion the history of society, a training in discovering their inter-relations, and also a training in reckoning as consciously with customs, habits, and

emotions as with other natural forces, engineers may be expected to coöperate in the advancement of human well-being with the effectiveness they have shown in advancing technology."

The final chapter, "The New Call to the Engineering Profession," is a high-minded appeal to members to play the larger part in promoting human welfare by reducing the waste of materials and of human energy, and by participating in community affairs. "And for American engineers it offers an opportunity to parallel their outstanding participation in the advancement of human comfort and convenience by making a vital contribution toward assuring the continuance of what has made and will keep their country free—the essence of democracy."

"The Engineering Profession" is a different book in the subject matter included and in its treatment. Parts are valuable to the inquiring high school boy; other portions are pertinent to orientation of the engineering student in college and still others emphasize the thought processes in engineering which will be good medicine for the junior engineer.

R. L. SACKETT

TRENDS IN COLLEGE-GRADE DEFENSE TRAINING

By R. A. SEATON *

During the first four months of the Engineering, Science, and Management Defense Training program which began July 1, 1941, a total enrollment of 163,097 persons in 142 institutions has been authorized. These figures are comparable with the maximum authorization of 137,656 trainees in 144 institutions in the Engineering Defense Training program for the seven months of the past fiscal year during which preliminary course proposals were approved. Actual enrollments in the Engineering Defense Training courses reached a cumulative total, by the end of June 1941, of 118,740; while the total enrollments in the courses after two weeks of instruction was 107,830. A somewhat similar relationship between authorized and actual enrollments may be expected in the Engineering, Science, and Management Defense Training courses, though it is not to be expected that the ratios will be identical with those of the Engineering Defense Training program.

Of the 163,097 enrollments already authorized in the new program, 2,568 were in courses for chemists and 898 in courses for physicists. In both of these groups the largest demand thus far is for basic courses for the in-service training of high-school graduates serving as laboratory assistants or in production work where such training will add to their effectiveness. At the other end of the scale, courses in advanced subjects of special application have also been approved for the training of workers who already have degrees, or at least several years of college education. There has, as yet, been little demand for courses between these two extremes.

Courses in production supervision for engineers constituted a substantial part of the Engineering Defense Training program of last year and a somewhat larger enrollment in such courses has already been authorized in the new program. It was expected that only a relatively small amount of defense training would be needed this year under the new classification of non-engineering production supervision. However, this need has developed far beyond our expectations. As of October 31, authorized enrollments in courses for non-engineering production supervisors totalled 17,093, and it had been necessary to increase the sum ear-marked for courses in

* Dean of the Division of Engineering and Architecture, Kansas State College, absent on leave to serve as Director of Engineering, Science, and Management Defense Training in the U. S. Office of Education.

this field from the original amount of $500,000 to $1,500,000. Over three-quarters of the enrollments so far authorized in this field have been in courses in personnel administration, accounting (principally cost accounting), and the fundamentals of production supervision.

So far as the courses for engineers are concerned, the Engineering, Science, and Management Defense Training program may be characterized as a continuation, on an enlarged scale, of the Engineering Defense Training program of last year. The pattern has changed only in minor details, chiefly in much larger relative enrollments in courses in Basic Sciences, Civil Engineering, and Electrical Engineering, and the large number of courses in Safety Engineering that have developed as a result of an intensive campaign by the Committee for the Conservation of Manpower in Defense Industries of the U. S. Department of Labor. An increasing interest is developing in courses in radio communications and ultra-high-frequency techniques, stimulated by a growing realization of the importance of electronic devices in the national defense.

In reviewing the accomplishments of the Engineering Defense Training and the Engineering, Science, and Management Defense Training programs up to the present time, the fact is noticeable that the greatest success in defense training, as measured by sustained student interest and by placements and promotions of trainees, is closely related to the closeness of coöperation between the colleges and the defense industries served. Defense training is job training, not general education. Its purpose is to give the instruction needed to fit students for specific kinds of work. This objective is best attained by early, complete, and whole-hearted coöperation between the college authorities, on the one hand, and responsible officials of defense industries and agencies on the other.

ENROLLMENT UNDERGRADUATE ENGINEERING STUDENTS, AS OF OCTOBER 6, 1941

Engineering Courses	Freshmen (1st year)	Sophomores (2nd year)	Juniors (3d year)	Seniors (4th year)	5th Year (of 5-yr. Curriculum)	Special Students	Evening Students	Others	Totals	No. of First Degrees Conferred During the Academic Year 1940–41
Aeronautical	1,476	1,242	967	704	44	8	296	1	4,738	435
Agricultural	237	161	124	158	3	0	0	2	685	156
Architectural	343	320	267	223	42	3	3	0	1,201	185
Ceramic	182	208	143	141	4	45	0	0	723	83
Chemical	4,600	4,393	3,531	2,883	318	96	779	0	16,600	2,398
Civil	2,805	2,861	2,247	2,185	133	55	529	23	10,838	1,430
Electrical	3,289	3,680	3,275	2,773	186	68	1,154	1	14,426	2,467
Industrial	448	643	619	637	29	16	252	0	2,644	552
Mechanical	7,093	7,592	5,647	4,548	353	188	1,913	461	27,795	3,618
Metallurgical	407	631	619	601	2	13	253	0	2,526	451
Mining	274	352	371	439	0	14	8	1	1,459	313
Naval Arch. & Marine	165	189	163	130	7	2	0	0	656	95
General	1,092	648	553	459	70	8	580	0	3,410	429
Petroleum	514	488	540	560	11	9	21	0	2,143	362
Unclassified	13,067	1,555	451	265	155	125	4,942	182	20,742	173
Totals	35,992	24,963	19,517	16,706	1,357	650	10,730	671	110,586	13,147

Enrollment of Undergraduate Engineering Students, 1941–42

Institutions	Freshmen (1st year)	Sophomores (2nd year)	Juniors (3d year)	Seniors (4th year)	5th Year (of 5-yr. Curriculum)	Special Students	Evening Students	Others	Totals		No. of First Degrees Conferred During the Academic Year	
									1940*	1941	1940–41	1940*
Akron	90	59	41	35	31	7	—	—	278	263	30	27
Ala. Poly	503	363	253	211	49	11	—	—	1,278	1,390	166	151
Ala. Uni	369	201	170	120	—	12	99	—	933	971	93	106
Alaska	19	24	24	19	—	4	—	—	122	90	16	18
Arizona	129	118	98	60	—	2	—	—	383	407	39	45
Arkansas	—	—	—	—	—	—	—	—	332	—	—	36
Bradley	—	—	—	—	—	—	—	—	109	—	—	—
Brooklyn	—	—	—	—	—	—	—	—	1,872	—	—	111
Brown	100	70	40	36	—	—	—	—	171	246	—	25
Bucknell	92	71	53	34	—	—	—	56	261	306	29	35
Calif. U	363	314	564	603	—	15	—	—	1,876	1,859	376	302
Calif. So. U	109	70	149	91	—	—	427	—	756	846	65	66
Calif. Tech	161	97	115	112	230	—	—	—	542	715	79	131
Carnegie	350	278	282	218	—	2	932	—	2,010	2,062	214	232
Case	317	251	200	191	—	—	670	36	1,706	1,665	195	166
Catholic	52	63	37	38	—	7	—	—	268	197	35	36
Cincinnati	459	242	216	215	182	—	302	—	1,601	1,616	181	144
Citadel	120	92	55	38	—	—	—	—	213	305	21	26
Clarkson	201	131	108	102	—	1	—	—	510	543	79	63
Clemson	413	284	140	111	—	—	—	—	880	948	103	65

* These data were published in the December 1940 Journal of Engineering Education.

Enrollment of Undergraduate Engineering Students, 1941–42—Continued

Institutions	Freshmen (1st year)	Sophomores (2nd year)	Juniors (3d year)	Seniors (4th year)	5th Year (of 5-yr. Curriculum)	Special Students	Evening Students	Others	Totals		No. of First Degrees Conferred During the Academic Year	
									1940*	1941	1940–41	1940*
Colo. St. Coll.	146	95	46	38	—	—	—	—	294	325	—	45
Colo. Mines	220	207	154	159	—	—	—	—	773	740	—	147
Colo. U.	320	217	155	170	—	—	—	—	867	862	139	143
Columbia	195	177	85	71	—	—	—	—	585	528	78	45
Conn.	—	—	—	—	—	—	—	—	230	—	—	6
Cooper (Day)	130	78	85	53	—	—	—	—	346	346	54	58
Cooper (Eve.)	256	167	184	135	109	88	—	—	994	939	86	60
Cornell	560	404	293	241	19	—	—	—	1,350	1,517	179	146
Dartmouth	—	—	—	32	11	—	—	—	23	43	—	—
Dayton	70	41	31	33	—	8	50	—	316	233	36	27
Delaware	88	60	46	35	—	5	—	—	226	234	34	32
Denver	75	29	18	14	—	—	—	—	152	136	25	21
Detroit	243	152	181	71	96	5	14	3	856	891	73	71
Drexel	365	250	131	102	98	1	—	—	880	947	113	102
Duke	114	64	42	52	—	—	—	—	234	272	36	26
Fenn	119	155	83	55	34	22	583	—	975	1,051	63	70
Florida	340	170	118	37	—	—	—	—	478	665	—	56
Ga. Sch. Tech.	799	725	466	331	13	7	—	—	2,198	2,341	320	275
Geo. Wash. U.	—	—	—	—	—	—	—	—	498	—	—	39
Gonzaga	60	47	25	15	—	—	—	—	152	147	11	2

Enrollment of Undergraduate Engineering Students, 1941–42—Continued

Institutions	Freshmen (1st year)	Sophomores (2nd year)	Juniors (3d year)	Seniors (4th year)	5th Year (of 5-yr. Curriculum)	Special Students	Evening Students	Others	Totals		No. of First Degrees Conferred During the Academic Year	
									1940*	1941	1940–41	1940*
Harvard†	——	67	41	38	——	——	——	14	110	160	35	45
Hawaii	49	37	11	14	——	——	——	23	132	134	9	——
Howard	51	9	7	2	——	——	——	——	54	69	4	5
Idaho	172	105	82	60	——	1	——	——	409	420	45	67
Ill. Inst. Tech	435	302	219	207	——	97	2,319	460	4,087	4,039	243	157
Illinois	876	557	459	399	——	——	——	——	2,290	2,291	399	387
Iowa St. Coll	685	580	383	300	——	5	——	——	1,956	1,953	257	260
Iowa Uni	——	——	——	——	——	——	——	——	480	——	——	68
Johns Hopkins	96	102	79	64	——	——	1,433	——	1,696	1,774	58	68
Kans. St. Coll	371	266	197	171	——	——	——	——	1,047	1,005	162	153
Kansas U	219	165	132	124	——	2	——	——	649	642	——	104
Kentucky	153	121	69	73	——	2	——	——	429	418	58	58
Lafayette	115	89	67	67	——	——	——	——	332	338	54	53
Lehigh	443	248	208	207	——	——	——	——	1,040	1,106	205	173
La. S. W. Inst	148	84	32	30	——	——	——	——	236	294	——	——
La. Uni	500	150	201	175	——	25	——	——	1,179	1,051	170	115
Louisville	127	85	60	45	——	——	51	——	324	368	31	33
Maine	194	169	118	131	——	4	——	——	611	616	98	59

† Eng. Science in Harvard College.

Enrollment of Undergraduate Engineering Students, 1941–42—Continued

Institutions	Freshmen (1st year)	Sophomores (2nd year)	Juniors (3d year)	Seniors (4th year)	5th Year (of 5-yr. Curriculum)	Special Students	Evening Students	Others	Totals		No. of First Degrees Conferred During the Academic Year	
									1940*	1941	1940–41	1940*
Manhattan	145	82	79	46	—	—	—	—	307	352	56	47
Marquette	226	173	140	94	94	8	—	—	613	735	80	—
Maryland	305	229	115	58	2	—	—	—	597	709	53	56
M. I. T.	646	498	472	463	7	—	—	—	2,050	2,086	—	409
Mich. M. & T.	193	173	171	171	—	—	—	—	772	708	123	127
Mich. St. C.	364	240	217	169	—	—	—	—	958	990	140	125
Mich. U.	590	556	502	422	—	10	—	—	2,052	2,080	395	410
Minnesota	584	562	454	455	45	1	416	35	2,091	2,552	357	348
Miss. St. C.	246	185	115	156	—	1	—	—	639	703	85	126
Miss. U.	25	20	14	7	—	—	—	—	71	66	12	—
Mo. Mines	195	218	181	216	—	—	—	—	870	810	147	156
Mo. U.	317	159	125	96	—	—	—	—	622	697	69	65
Mont. St. C.	188	144	81	69	—	—	—	—	475	482	73	75
Mont. Mines	76	74	51	48	—	2	—	—	290	251	48	—
Nebraska	351	182	106	87	—	—	—	—	781	726	90	84
Nevada	96	50	46	35	—	7	—	—	221	234	—	—
Newark	193	179	121	89	—	—	138	—	705	720	100	148
New Hampshire	152	107	98	65	—	—	—	—	390	424	60	58
New Mex. U.	105	69	50	29	—	—	—	—	251	253	—	19
New Mex. A. M.	—	—	—	—	—	—	—	—	182	—	—	19
New Mex. Mines	24	32	27	30	—	—	—	—	141	113	—	—
N. Y. Ceramics	94	97	62	53	4	1	—	—	228	311	—	39
N. Y. City College	1,013	564	351	305	—	—	1,545	—	3,278	3,778	214	209

N. Y. City College	1,013	564	351	305	—	—	1,545	—	3,278	3,778	214	209

Enrollment of Undergraduate Engineering Students, 1941–42—Continued

Institutions	Freshmen (1st year)	Sophomores (2nd year)	Juniors (3d year)	Seniors (4th year)	5th Year (of 5-yr. Curriculum)	Special Students	Evening Students	Others	Totals		No. of First Degrees Conferred During the Academic Year	
									1940*	1941	1940–41	1940*
New York U.	284	298	230	191	—	34	1,174	30	2,193	2,241	263	240
No. Car.	615	357	194	186	—	—	—	—	1,322	1,352	—	141
N. D. St. C.	111	72	45	49	—	47	—	—	326	324	30	—
N. D. Uni.	71	71	30	36	—	42	—	—	272	250	30	34
Northeastern	489	398	274	215	205	—	—	—	1,483	1,581	196	135
Northwestern	242	167	84	39	—	5	—	—	398	537	36	39
Norwich	105	77	44	39	—	—	—	—	228	265	27	—
Notre Dame	223	156	118	57	—	—	—	—	529	554	—	62
Ohio St. U.	590	544	330	287	9	—	—	—	1,800	1,760	296	262
Ohio U.	—	—	—	—	—	—	—	—	242	—	—	—
Ohio No.	57	35	29	32	—	—	—	—	157	153	29	—
Okla. A. M.	411	237	209	177	8	4	—	—	1,220	1,046	130	142
Okla. U.	465	326	385	375	—	—	—	—	1,551	1,551	238	—
Ore. St. C.	429	220	165	157	—	—	—	—	961	971	121	119
Pa. St. C.	715	575	361	331	—	7	—	—	1,718	1,989	290	293
Pa: Towne Sci.	148	102	71	66	—	—	—	—	345	387	54	57
Moore Sc. E. E.	31	23	21	16	—	—	—	—	89	91	24	14
Pittsburgh	310	251	228	212	—	24	320	—	1,285	1,345	181	173
Porto Rico	—	—	—	—	—	—	—	—	313	—	—	43
Pratt	196	150	109	91	—	—	—	—	558	546	81	81
Princeton	168	113	99	77	15	—	—	—	404	472	—	56
Purdue	1,179	885	780	596	—	4	—	—	3,487	3,444	550	522

Enrollment of Undergraduate Engineering Students, 1941–42—Continued

Institutions	Freshmen (1st year)	Sophomores (2nd year)	Juniors (3d year)	Seniors (4th year)	5th Year (of 5-yr. Curriculum)	Special Students	Evening Students	Others	Totals		No. of First Degrees Conferred During the Academic Year	
									1940*	1941	1940–41	1940*
Rensselaer	395	325	219	285	—	5	—	—	1,260	1,229	238	198
R. I. St. C.	110	93	53	58	—	—	—	—	321	314	51	49
Rice	181	150	106	109	—	—	—	—	534	546	69	55
Rochester	76	49	33	28	—	2	—	—	172	188	28	16
Rose	125	91	61	48	—	—	—	—	283	325	41	34
Rutgers	115	65	46	38	—	4	—	—	250	268	38	—
Santa Clara	60	19	23	19	—	—	—	—	80	121	9	9
So. Car.	100	60	45	25	—	—	—	—	204	230	20	14
So. Dak. C.	115	66	31	31	—	1	—	—	230	244	30	—
So. Dak. Mines	152	95	74	45	—	—	—	—	311	366	45	73
So. Meth.	78	59	38	29	21	1	—	—	196	226	16	15
Stanford	200	—	110	121	—	—	—	—	417	431	97	74
Stevens	205	168	143	113	—	—	—	—	620	629	119	91
Swarthmore	32	26	22	9	—	—	—	—	73	89	11	14
Syracuse	204	126	78	78	—	—	—	—	438	486	75	67
Tenn. Poly.	63	40	13	9	—	—	—	—	178	125	9	—
Tenn. U.	280	161	144	87	—	4	—	—	738	676	72	64
Texas A. M.	1,417	763	588	437	13	1	—	—	3,101	3,219	335	241
Texas U.	562	299	341	221	—	—	—	—	1,476	1,423	216	—
Texas Tech.	208	182	128	165	—	—	—	—	739	683	78	62
Texas A. I.	67	31	27	17	—	—	—	—	197	142	—	18
Toledo	143	87	76	45	3	—	217	—	584	571	38	29

Texas A. I.	67	31	27	17	—	—	—	—	197	142	—	18
Toledo	143	87	76	45	3	—	217	—	584	571	38	29

Enrollment of Undergraduate Engineering Students, 1941–42—Continued

Institutions	Freshmen (1st year)	Sophomores (2nd year)	Juniors (3d year)	Seniors (4th year)	5th Year (of 5-yr. Curriculum)	Special Students	Evening Students	Others	Totals		No. of First Degrees Conferred During the Academic Year	
									1940*	1941	1940–41	1940*
Tufts	139	110	75	81	—	—	—	—	394	405	83	77
Tulane	195	84	73	49	—	—	—	2	371	403	48	36
Tulsa	—	—	—	—	—	—	—	—	214	—	—	26
Union	97	39	28	37	—	—	—	—	164	201	32	23
U. S. Coast Guard	145	92	73	31	—	—	—	—	261	341	22	—
Utah Ag. C.	73	33	40	22	—	—	—	—	212	168	35	—
Utah U.	187	171	118	52	—	—	—	—	515	528	64	—
Valparaiso	34	17	4	—	—	—	—	1	40	56	—	—
Vanderbilt	95	72	51	37	3	—	—	—	232	258	—	—
Vermont	36	37	34	18	—	—	—	—	133	125	22	19
Villanova	99	82	63	40	—	—	—	—	242	284	40	38
Va. Mil. Inst.	138	130	94	76	—	—	—	—	381	438	62	79
Va. Poly. Inst.	839	445	307	279	—	—	—	—	1,695	1,870	257	248
Va. Uni.	80	51	59	36	—	—	—	—	249	226	38	26
Wash. U. (St. Louis)	194	104	80	68	—	10	—	—	377	456	69	—
Wash. U.	753	209	195	253	—	—	20	—	1,444	1,430	184	176
Wash. St. C.	157	106	88	86	—	1	—	—	629	438	74	80
Wayne	223	151	112	90	—	7	20	—	655	603	57	—
Webb	20	18	14	16	—	—	—	—	63	68	13	13
W. Va.	212	148	105	65	—	3	—	1	508	534	73	87
Wisconsin	482	391	303	289	—	73	—	—	1,472	1,538	218	199

Enrollment of Undergraduate Engineering Students, 1941–42—Continued

Institutions	Freshmen (1st year)	Sophomores (2nd year)	Juniors (3d year)	Seniors (4th year)	5th Year (of 5-yr. Curriculum)	Special Students	Evening Students	Others	Totals		No. of First Degrees Conferred During the Academic Year	
									1940*	1941	1940–41	1940*
Worcester	195	153	128	107	—	—	—	—	605	583	113	—
Wyoming	166	80	50	58	—	—	—	—	359	354	52	38
Yale	—	117	79	94	—	—	—	—	239	290	54	74
U. S. Schools Total	34,993	24,349	19,009	16,291	1,311	647	10,730	661	108,911	108,091	12,709	11,192
Canadian Schools												
Alberta	—	—	—	—	—	—	—	—	299	—	—	—
Ecole Poly	121	74	48	35	44	—	—	—	293	222	33	30
McGill	—	—	—	—	—	—	—	—	—	—	—	—
New Brunswick	42	32	23	21	—	—	—	—	—	118	23	—
Nova Scotia	—	—	—	—	—	—	—	—	57	—	—	—
Queen's	199	136	119	103	—	3	—	10	588	570	124	136
Saskatchewan	166	111	84	77	—	—	—	—	470	438	72	—
Toronto	471	261	234	179	2	—	—	—	—	1,147	186	—
Canadian	999	614	508	415	46	3	—	10	1,707	2,495	438	166
United States	34,993	24,349	19,009	16,291	1,311	647	10,730	661	108,911	108,091	12,709	12,358
Totals	35,992	24,963	19,517	16,706	1,357	650	10,730	671	110,618	110,586	13,147	12,524

Totals	35,992	24,963	19,517	16,706	1,357	650	10,730	671	110,618	110,586	13,147	12,524

Graduate Engineering Enrollment, 1941–42

Engineering Courses	Enrollment in Work for the Master's Degree								Enrollment in Work for the Doctor's Degree							
	Full-Time Resident Students	Part-Time Resident Students	Evening Students	Others	Total* 1940	Total† 1941	Masters Degrees Conferred in		Full-Time Resident Students	Part-Time Resident Students	Evening Students	Others	Total 1940	Total 1941	Doctors Degree Conferred in	
							1940–41	1940							1940–41	1940
Aeronautical	89	59	—	—	130	148	72	47	14	7	—	—	24	21	3	5
Agricultural	9	18	—	—	28	27	20	25	1	4	—	1	3	6	2	—
Architectural	14	4	—	—	21	18	5	7	1	—	—	—	1	1	1	—
Ceramic	7	6	1	—	14	14	7	17	9	—	—	—	20	9	5	3
Chemical	253	155	470	29	910	907	372	321	123	100	23	25	237	271	86	38
Civil	137	111	200	—	603	448	239	300	30	27	12	19	66	88	26	9
Electrical	166	72	583	1	984	822	212	214	43	43	11	3	120	100	20	20
Industrial	29	17	67	—	178	113	24	15	15	6	1	—	2	22	2	—
Mechanical	165	108	457	2	895	732	181	170	18	18	—	1	48	37	7	7
Metallurgical	58	20	64	—	216	142	67	59	31	9	1	3	49	44	14	8
Mining	36	3	1	—	63	40	23	29	—	2	—	—	7	2	1	2
Unclassified	268	171	150	2	556	591	149	124	27	12	—	—	46	39	10	13
Totals	1,231	744	1,993	34	4,598	4,002	1,372	1,329	312	228	48	52	623	640	177	108

* 95 schools reported in 1940.
† 91 schools reported in 1941.

Graduate Engineering Enrollment, 1941–42—Continued

Institutions	Enrollment in Work for the Master's Degree								Enrollment in Work for the Doctor's Degree							
	Full-Time Resident Students	Part-Time Resident Students	Evening Students	Others	Total 1940	Total 1941	Masters Degrees Conferred in		Full-Time Resident Students	Part-Time Resident Students	Evening Students	Others	Total 1940	Total 1941	Doctors Degree Conferred in	
							1940–41	1939–40							1940–41	1939–40
Ala. Poly	6	—	—	—	5	6	5	4	—	—	—	—	—	—	—	—
Ala. Uni	2	—	—	—	6	2	5	4	—	—	—	—	—	—	—	—
Arizona	4	—	—	—	8	4	7	3	—	—	—	—	—	—	—	—
Arkansas	—	—	—	—	2	—	—	0	—	—	—	—	—	—	—	—
Brooklyn	1	6	278	—	270	285	29	26	—	7	25	—	23	32	2	—
Brown	—	2	—	—	—	2	—	1	—	—	—	—	—	—	—	—
Cal. Tech	159	—	—	—	103	159	104	57	25	—	—	—	26	25	4	10
Cal. Uni	73	—	—	—	113	73	24	37	—	—	—	—	—	—	1	2
Cal. So. U	—	15	—	—	25	15	6	10	—	2	—	—	—	2	1	—
Carnegie	16	—	66	—	113	82	17	15	14	—	—	—	9	14	2	2
Case	1	33	101	2	85	137	22	28	—	3	3	—	8	6	—	1
Catholic	—	14	—	—	10	14	0	5	—	—	—	—	—	—	—	—
Cincinnati	14	11	—	—	23	25	4	11	2	—	—	—	8	2	8	6
Colo. Mines	11	—	—	—	14	11	3	7	—	—	—	—	—	—	—	—
Colo. Uni	—	49	—	—	56	49	—	14	—	—	—	—	—	—	—	—
Columbia	45	62	43	—	—	150	72	—	13	30	—	39	—	82	15	—
Connecticut	—	18	—	—	38	18	0	0	—	—	—	—	—	—	—	—
Cornell	26	—	—	—	23	26	30	39	19	—	—	—	19	19	14	3
Delaware	—	4	—	27	34	31	2	38	—	—	—	—	—	—	—	—
Florida	3	—	—	—	6	3	0	0	—	—	—	—	—	—	—	—

Institutions	Enrollment in Work for the Master's Degree								Enrollment in Work for the Doctor's Degree							
	Full-Time Resident Students	Part-Time Resident Students	Evening Students	Others	Total 1940	Total 1941	Masters Degrees Conferred in		Full-Time Resident Students	Part-Time Resident Students	Evening Students	Others	Total 1940	Total 1941	Doctors Degree Conferred in	
							1940–41	1939–40							1940–41	1939–40
Florida	3	—	—	—	6	3	0	0	—	—	—	—	—	—	—	—

Graduate Engineering Enrollment, 1941–42—Continued

Institutions	Enrollment in Work for the Master's Degree								Enrollment in Work for the Doctor's Degree							
	Full-Time Resident Students	Part-Time Resident Students	Evening Students	Others	Total 1940	Total 1941	Masters Degrees Conferred in		Full-Time Resident Students	Part-Time Resident Students	Evening Students	Others	Total 1940	Total 1941	Doctors Degree Conferred in	
							1940–41	1939–40							1940–41	1939–40
Ga. Tech	—	18	—	—	26	18	6	16	—	—	—	—	—	—	—	—
Harvard	49	16	—	—	108	65	72	97	11	10	—	—	32	21	7	8
Idaho	3	—	—	—	5	3	2	9	—	—	—	—	—	—	—	—
Ill. Tech	25	—	266	—	328	291	17	24	11	1	—	—	13	12	0	0
Ill. Uni	6	29	—	—	49	35	27	27	4	16	—	—	31	20	7	6
Iowa St. C	1	21	—	—	42	22	15	27	—	16	—	—	18	16	4	0
Iowa Uni	—	—	—	—	31	—	—	24	—	—	—	—	14	—	—	3
J. Hopkins	2	6	—	1	22	9	1	2	12	12	—	2	29	26	8	4
Kansas St. C	3	19	—	—	33	22	7	9	—	—	—	—	—	—	—	—
Kansas U	4	3	—	—	6	7	—	4	—	—	—	—	—	—	—	—
Kentucky	—	2	—	—	2	2	3	—	—	—	—	—	—	—	—	—
Lafayette	2	—	—	—	2	2	1	3	—	—	—	—	—	—	—	—
Lehigh	7	35	—	—	51	42	26	35	2	9	—	—	19	11	4	0
Louisville	7	1	15	—	30	23	7	11	—	—	—	—	—	—	—	—
La. S. W. Inst	—	—	—	—	236	—	—	0	—	—	—	—	—	—	—	—
Louisiana U	5	2	—	—	18	7	3	10	—	—	—	—	1	—	1	0
Maine	—	5	—	—	12	5	5	2	—	—	—	—	—	—	—	—
Maryland	—	4	—	—	4	4	0	0	1	—	—	—	4	1	3	1

Graduate Engineering Enrollment, 1941–42—Continued

Institutions	Enrollment in Work for the Master's Degree								Enrollment in Work for the Doctor's Degree							
	Full-Time Resident Students	Part-Time Resident Students	Evening Students	Others	Total 1940	Total 1941	Masters Degrees Conferred in		Full-Time Resident Students	Part-Time Resident Students	Evening Students	Others	Total 1940	Total 1941	Doctors Degree Conferred in	
							1940–41	1939–40							1940–41	1939–40
M. I. T.	228	—	—	—	333	228	205	227	106	—	—	—	122	106	28	21
Mich. Mines	1	—	—	—	5	1	3	3	—	—	—	—	—	—	—	—
Mich. Uni.	63	—	—	—	144	63	122	117	35	—	—	—	54	35	12	7
Mich. St. C.	—	8	—	—	19	8	5	4	—	—	—	—	—	—	—	—
Minnesota	6	29	—	—	94	35	28	31	9	28	—	5	7	42	5	7
Mo. Mines	8	2	—	—	16	10	4	4	—	—	—	—	2	—	—	0
Missouri	4	14	—	—	25	18	12	5	—	2	—	—	—	2	—	—
Mont. Mines	13	—	—	—	16	13	7	10	—	—	—	—	—	—	—	—
Mont. St. C.	1	—	—	—	2	1	0	1	—	—	—	—	—	—	—	—
Nebraska	2	—	—	—	6	2	3	2	—	—	—	—	1	—	—	1
Newark	—	—	120	—	104	120	—	0	—	—	—	—	—	—	—	—
New Hampshire	—	4	—	—	4	4	8	5	—	—	—	—	—	—	—	—
N. Y. Ceramics	—	3	—	—	1	3	0	0	—	—	—	—	—	—	—	—
N. Y. C. C.	22	—	—	—	—	22	5	0	—	—	—	—	—	—	—	—
N. Y. Uni.	74	39	227	—	348	340	47	34	—	6	20	—	23	26	1	0
No. Car. St. C.	11	—	—	—	23	11	6	12	—	—	—	—	—	—	—	—
Northwestern	—	—	37	—	30	37	1	2	—	—	—	—	—	—	—	—
No. Dak. U.	—	3	—	—	1	3	3	5	—	—	—	—	—	—	—	—
Notre Dame	—	—	—	—	5	—	—	0	—	—	—	—	—	—	—	—
Ohio State	14	8	—	2	40	24	25	27	11	11	—	6	25	28	14	7
Okla. Uni.	9	—	—	—	—	9	9	—	—	—	—	—	—	—	—	—

Graduate Engineering Enrollment, 1941–42—Continued

Institutions	Enrollment in Work for the Master's Degree								Enrollment in Work for the Doctor's Degree							
	Full-Time Resident Students	Part-Time Resident Students	Evening Students	Others	Total 1940	Total 1941	Masters Degrees Conferred in		Full-Time Resident Students	Part-Time Resident Students	Evening Students	Others	Total 1940	Total 1941	Doctors Degree Conferred in	
							1940–41	1939–40							1940–41	1939–40
Okla. A. M.	6	—	—	—	15	6	15	17	—	—	—	—	—	—	—	—
Oregon	3	6	—	—	12	9	10	1	—	—	—	—	—	—	—	—
Pa. St. C.	5	23	—	—	44	28	16	27	—	16	—	—	22	16	7	2
Pa.: Towne	—	—	103	—	100	103	3	6	—	—	—	—	5	—	—	—
Moore	5	—	98	—	84	103	4	2	2	10	—	—	13	12	0	0
Pittsburgh	3	30	218	—	297	251	34	12	—	15	—	—	—	15	2	4
Princeton	15	—	—	—	15	15	14	14	—	—	—	—	—	—	—	—
Purdue	24	18	—	—	68	42	48	27	—	19	—	—	30	19	5	2
Rensselaer	12	7	—	—	25	19	16	20	—	—	—	—	—	—	—	—
Rhode Island	0	0	—	—	1	0	1	0	—	—	—	—	—	—	—	—
Rice	2	—	—	—	2	2	2	0	—	—	—	—	—	—	—	—
Rochester	3	5	—	—	6	8	3	3	—	—	—	—	—	—	—	—
Rutgers	—	4	—	—	8	4	3	3	—	—	—	—	—	—	—	—
So. Dak. Mines	—	1	—	—	3	1	1	2	—	—	—	—	—	—	—	—
So. Dak. St. C.	—	—	—	—	3	—	—	0	—	—	—	—	—	—	—	—
Stanford	71	—	—	—	96	71	32	28	—	—	—	—	—	—	7	—
Stevens	1	16	410	—	337	427	18	5	—	—	—	—	—	—	—	—
Syracuse	1	3	—	—	—	4	3	—	—	—	—	—	—	—	—	—
Tennessee	26	18	—	—	41	44	—	11	—	—	—	—	—	—	—	—
Texas A. M.	5	15	—	—	29	20	15	8	2	3	—	—	4	5	—	0

Graduate Engineering Enrollment, 1941–42—Continued

Institutions	Enrollment in Work for the Master's Degree								Enrollment in Work for the Doctor's Degree							
	Full-Time Resident Students	Part-Time Resident Students	Evening Students	Others	Total 1940	Total 1941	Masters Degrees Conferred in		Full-Time Resident Students	Part-Time Resident Students	Evening Students	Others	Total 1940	Total 1941	Doctors Degree Conferred in	
							1940–41	1939–40							1940–41	1939–40
Texas Uni.	4	57	—	—	48	61	25	0	3	8	—	—	17	11	2	5
Texas Tech.	—	—	—	—	2	—	—	3	—	—	—	—	—	—	—	—
Tulane	—	8	—	—	9	8	1	3	—	—	—	—	—	—	—	—
Tulsa	—	—	—	—	5	—	—	0	—	—	—	—	—	—	—	—
Union	—	—	—	—	1	—	—	0	—	—	—	—	—	—	—	—
Utah Ag. C.	—	—	—	—	2	0	1	0	—	—	—	—	—	—	—	—
Utah Uni.	6	—	—	—	5	6	4	4	—	—	—	—	—	—	—	—
Vermont	—	—	—	—	1	—	—	0	—	—	—	—	—	—	—	—
Va. Poly.	22	22	—	—	51	44	20	33	2	1	—	—	2	3	0	0
Va. Uni.	1	—	—	—	2	1	2	3	—	—	—	—	—	—	—	—
Wash. St. C.	1	—	—	—	3	1	1	0	—	—	—	—	—	—	—	—
Wash., Uni. of	10	—	—	—	22	10	14	14	—	—	—	—	—	—	—	—
Wash. U. (St. Louis)	6	—	11	2	—	19	2	0	—	—	—	—	—	—	—	—
West Va.	—	2	—	—	11	2	6	8	—	—	—	—	—	—	—	—
Wisconsin	38	4	—	—	32	42	15	16	—	—	—	—	9	—	—	7
Worcester	—	9	—	—	15	9	4	4	—	—	—	—	—	—	—	—
Wyoming	—	—	—	—	1	—	—	0	—	—	—	—	—	—	—	—
Yale	23	—	—	—	27	23	10	16	27	—	—	—	33	27	10	8

Yale	23	—	—	—	27	23	10	16	27	—	—	—	33	27	10	8

Graduate Engineering Enrollment, 1941–42—Continued

Institutions	Enrollment in Work for the Master's Degree								Enrollment in Work for the Doctor's Degree							
	Full-Time Resident Students	Part-Time Resident Students	Evening Students	Others	Total 1940	Total 1941	Masters Degrees Conferred in		Full-Time Resident Students	Part-Time Resident Students	Evening Students	Others	Total 1940	Total 1941	Doctors Degree Conferred in	
							1940–41	1939–40							1940–41	1939–40
U. S. Schools Totals...	1,224	731	1,993	34	4,582	3,982	1,358	1,318	311	225	48	52	623	636	174	108
Canadian Schools:																
Ecole Poly.....	—	3	—	—	1	3	1	0	—	—	—	—	—	—	1	0
Queen's.....	2	—	—	—	11	2	0	6	—	—	—	—	—	—	—	—
Saskatchewan.....	—	1	—	—	4	1	5	2	—	—	—	—	—	—	—	—
Toronto.....	5	9	—	—	—	14	8	1	1	3	—	—	—	4	2	—
Totals.....	1,231	744	1,993	34	4,598	4,002	1,372	1,327	312	228	48	52	623	640	177	108

COMPARISON OF ENROLLMENT, 1940–41 AND 1941–42

UNDERGRADUATE

The comparison is between the attendance of 117 schools which reported both years:

Year	Freshmen	Sophomores	Juniors	Seniors	Total
1941–42	30,438	21,157	16,096	13,596	81,286
1940–41	26,673	20,144	16,057	13,316	76,190
Increase	3,765	1,013	39	280	5,096
Per cent inc.	14.1%	5%	.2%	2.1%	6.6%

(Evening enrollment decreased 8.9%)

GRADUATE

81 institutions reporting both years:

Year	Enrolled for M.S.	Degrees Conferred	Enrolled for Ph.D.	Degrees Conferred
1941–42	3,666	1,291	617	160
1940–41	4,012	1,201	593	92
	−346	+90	+24	+68

NOTE: The American Association of Junior Colleges reports that enrollments in public junior colleges show an average drop of 10% from those of last year, while in private junior colleges there has been a slight increase of less than 1%.

THE ENGINEERING COLLEGE AND THE WAR

By ALFRED H. WHITE, President

The declaration of war has inevitably raised in our minds the query whether there is something more for us to do, something that we are not now doing. Our country has been fortunate in its leadership which foresaw that war would almost unavoidably be forced upon us, and started preparations more than 18 months ago. The huge defense programs that are now well under way will have to be supplemented by more gigantic programs. It is certain that our effort must be extended beyond the manufacture and distribution of the implements of war. We must now train men competent to direct the machines we have built and are going to build.

We have been fortunate in the leadership of those responsible for the administration of the Selective Service Act and their appreciation of the value of college men. Both the Army and Navy have recognized the great need of engineers with thorough training. The work done in refresher courses has been good and has helped those who were rusty in their training to bring themselves to a higher level of proficiency. These short courses could not and were not expected to take untrained men and make experts of them. Our undergraduates in engineering and our graduate students have, for the most part, been encouraged to stay at their tasks and finish their training. Those of us who are old enough to remember events on our campuses nearly 25 years ago recall the enthusiasm with which college students enlisted, in the belief that they were doing the best thing for their country. The Army tried to pick out the best men from the volunteers and from the drafted men and train them as specialists and as officers. As the war progressed, it was recognized that it would have been better if more of the young men had completed their professional training before commencing military service.

The proportion of skilled personnel in this war will be much higher than in 1918. The professional engineers in civilian life have been extremely busy with the munitions program and have, for the most part, been reserved for that program. Where will our fighting forces get the young men necessary to operate the machines of war?

The part which our engineering colleges should take in the war effort was discovered at a meeting of the Executive Committee of

our Society in Chicago on December 14, 1941, when it was decided to take a poll of all of our colleges by telegraph. Our Committee on Acceleration of Regular Engineering Programs met in Pittsburgh on December 17, 1941, and canvassed the 125 replies which had been received. Their deliberations resulted in a report which was presented to Commissioner Studebaker of the U. S. Office of Education in Washington on December 18, 1941, and to the Advisory Committee of the E. S. M. D. T. program on December 19, 1941. Mr. Sidney Hillman, Associate Director of O. P. M. attended one of the meetings and assured the group that the shortage of technically trained men was indeed acute. He asked that the group initiate a program to graduate as many engineers as soon as possible without impairment of their quality. The representatives of the Army who were present concurred with Mr. Hillman and told us that engineering students should be encouraged to stay in school until they had completed their work. The recommendations of the Advisory Committee are printed elsewhere in this issue and can only be carried out in full if Congress appropriates funds to cover the additional cost to the schools. Even then each college must decide for itself just how far it can go in meeting the emergency.

War will inevitably bring changes to our colleges and to all our lives. But whatever the changes, the colleges, the teachers and the students will continue to do their part patriotically and wholeheartedly. Our task is to carry on with renewed energy and give our students the best that is in us.

REPORT OF COMMITTEE ON ACCELERATION OF REGULAR ENGINEERING PROGRAMS

PITTSBURGH, PA., DECEMBER 17, 1941

The following report was prepared from the information received from the engineering faculties of the United States.

The declaration of war by the United States following the attack by the Japanese forces undoubtedly requires an increase in the speed and extent of the preparedness program. The demand for engineers in both military and civilian service will grow correspondingly. The engineering colleges expect to take their proper part in meeting this demand. In order to determine what steps can and should be taken the Committee on Acceleration of Regular Engineering Programs of the Society for the Promotion of Engineering Education asked engineering college administrators by telegraph to express the attitude of their institutions on the following five items:

1. Conducting required summer terms.
2. Curtailing the curriculum in addition to summer operation.
3. Graduating present seniors before June.
4. Federal financial assistance for colleges and students.
5. Deferment of students under selective service, or induction and assignment to the colleges.

Replies, representing the opinion of perhaps 1,000 engineering educators, were received from 125 colleges within 48 hours. The Committee met in Pittsburgh on December 17, 1941, and after thorough study and discussion of the replies it recommends that:

1. The present senior class in engineering be graduated as early as possible consistent with the maintenance of a sound engineering educational program.

2. Engineering curricula not be curtailed; but believes that, because of the urgent need for specialized training for the war effort, substitutions for non-engineering subjects of courses pertinent to the conduct of the war will assist materially in meeting expected needs.

3. In addition to the early graduation of the class of 1942, summer sessions be inaugurated for the purpose of graduating the pres-

ent junior classes (1943) in February, 1943, and the present sophomore classes (1944) in September or October, 1943.

4. The additional cost to the colleges in carrying out this recommended accelerated program, not covered by tuition, be borne by the Federal government.

5. A student loan fund be provided by Federal appropriation to assist needy students who are deprived of the opportunity to earn during the summer months, and that sums under this appropriation be made available to engineering schools and be administered by them as agents of the Federal government.

6. The Federal appropriation necessary to make possible the operation of engineering colleges on the accelerated basis be allocated by the U. S. Office of Education under the E. S. M. D. T.

7. Coöperative colleges study the problem of accelerated programs in the light of the special conditions under which they operate.

8. In view of the necessity for financial aid to the colleges, this report be presented to the U. S. Commissioner of Education as a plan for the operation of engineering colleges during the emergency.

9. The U. S. Commissioner of Education take the necessary steps to obtain the required appropriations, if he approves this plan.

10. Engineering students in good standing be deferred by the Selective Service Boards until they have completed the accelerated program.

Unless engineering students are permitted to remain in college, as recommended under item 10, the objectives of an accelerated program will be defeated.

The Committee estimates that the recommended plan would affect approximately 40,000 students now enrolled in the junior and sophomore classes. For the operation of the regular terms, the colleges now require their tuition fees in addition to income from endowment or public appropriation. For the operation of a third term each year, income in excess of tuition will be required. The Committee estimates this amount to be approximately $7,200,000.

For loans to needy students, recommended under item 5, the Committee believes that an additional sum of $2,500,000 annually will be required.

(signed) IVAN C. CRAWFORD, F. L. WILKINSON,
H. T. HEALD, A. H. WHITE,
C. E. MACQUIGG, F. L. BISHOP,
E. L. MORELAND, D. B. PRENTICE, *Chairman*

R. W. Sorensen, member of the Committee, unable to attend.

Federal Security Agency
U. S. Office of Education
Washington

Engineering, Science, and
Management Defense
Training

December 19, 1941

To: President A. H. White,
President, Society for the Promotion of Engineering Education
From: A. A. Potter,
Chairman, National Advisory Committee on Engineering, Science, and Management Defense Training
U. S. Office of Education
Re: Expediting Graduation in the Regular Engineering Programs of Study

The report of your Committee and its recommendations of December 17, 1941, received the careful consideration of the National Advisory Committee to the U. S. Office of Education on Engineering, Science, and Management Defense Training, and the following recommendations were made to the Commissioner of Education.

1. That institutions offering degrees in Engineering be advised to graduate the present seniors (1942 class) as early as possible consistent with the maintenance of sound engineering educational programs.

2. That a plan be developed to seek Federal support so that colleges and universities may be in a position to expedite the graduation of other engineering classes without financial loss to the institutions or undue hardship to students.

Cordially yours,
(signed) A. A. Potter

Federal Security Agency
U. S. Office of Education
Washington

Engineering, Science, and
Management Defense
Training

January 9, 1942

To: Dr. F. L. Bishop,
Secretary, S. P. E. E., University of Pittsburgh
From: A. A. Potter,
Chairman, National Advisory Committee on Engineering, Science, and Management Defense Training
U. S. Office of Education
Re: Expediting Graduation in the Regular Engineering Programs of Study

Supplementing my letter of December 19, 1941, addressed to the President of the S. P. E. E., the membership of the Society will be interested to

know that the National Advisory Committee on ESMDT met again in Washington on January 8, 1942, and made recommendations to the Commissioner of Education as indicated in the attached resolution.

Steps are being taken to secure Federal funds to cover additional cost to institutions and students resulting from the recommended program.

Pending final decision of Congress regarding Federal aid, institutions are advised to make only tentative plans regarding expedited programs and to put into effect only such changes as their budgets will permit. General Hershey advised that there has been no change in attitude of Selective Service toward engineering students.

A proposed estimate was submitted to the Commissioner with the attached statement which included details regarding additional costs to institutions and to students of the proposed program, and which should be borne by the Federal Government if an adequate supply of engineering, scientific and supervisory personnel is to be made available to meet the present national crisis.

Cordially yours,

Enclosure (signed) A. A. POTTER

Note: Sent to the President and Dean of every engineering college in the United States, Hawaii and Puerto Rico.

E. S. M. D. T. NATIONAL ADVISORY COMMITTEE

RESOLUTIONS FOR PRESENTATION TO THE COMMISSIONER OF EDUCATION

"The Nation is engaged in a total war effort that will tax its resources of materials, production, and men to the limit of its capacity.

"Provision of supervisory staff and technical trained personnel for both industry and the armed forces is indispensable to the war effort.

"Colleges and universities which are the instrumentalities primarily concerned in providing such personnel, desire to make the greatest possible contribution to this effort.

"It should be the purpose of higher education to effect such changes in its programs and procedures as are necessary to provide to the fullest possible extent the trained personnel required both for the immediate future and for a longer period ahead by the war effort.

"Since it is clear from all obtainable evidence that the number of graduates now produced by colleges and universities in the fields of engineering, chemistry, physics, and production supervision is inadequate to meet the needs of the present war, the National Advisory Committee on Engineering, Science, and Management De-

fense Training with a view toward meeting this deficiency, submits the following resolutions:

"*Resolved,* That it is the judgment of the National Advisory Committee on Engineering, Science, and Management Defense Training that the all-out war effort demands an increased supply of trained personnel in Engineering, Physics, Chemistry, and Production Supervision, and that all feasible steps should be taken to bring about the increased supply.

"*Further resolved,* That the Committee recommends that an expedited program be undertaken in these fields, without curtailment of curricular content, beginning with the 1942 Senior class and extending to and including the Freshman class entering in 1942.

"*Resolved further,* That steps be taken, if practicable, to increase the total numbers of persons enrolled in these fields at any given time.

"*Resolved further,* That an adequate supply of advanced students in the fields mentioned be maintained in order to meet the shortage of teaching and research personnel.

"*Provided,* however, that the institutions are protected against financial loss due to the expedited and increased program, and provided further that such a program should not be urged upon those institutions which, in view of their own circumstances, believe that the objective of an increased supply of trained personnel would be better attained by other means."

FIFTIETH ANNUAL MEETING OF THE SOCIETY FOR THE PROMOTION OF ENGINEERING EDUCATION

By HAROLD E. WALTER *

The Fiftieth Annual Meeting of any Society suggests something that is significant about the history of the Society. Just so will it be with our meeting scheduled to be held in New York City, June 29th to July 2nd, 1942. This history expresses more emphatically than words possibly can the value of the service which this Society offers to its members. Moreover, true consideration will emphasize the challenging aspect of this circumstance and may well imply a need for increased effort if the group is to continue the gains made during its first forty-nine years. In offering to serve as host for this exceptional assembly, some twelve institutions in the New York Metropolitan area in coöperation with the Middle Atlantic Section of S. P. E. E. are accepting the challenge which this Convention, through you, will provide. These institutions are:

College of the City of New York
Columbia University
Cooper Union
Manhattan College
New York University
Newark College of Engineering
Polytechnic Institute of Brooklyn
Pratt Institute
Princeton University
Rutgers University
Stevens Institute of Technology
Webb Institute of Naval Architecture.

This list includes every institution offering engineering courses of college grade in the New York area. Each of these institutions subscribes to the idea that we should provide a meeting which will be long remembered by all who attend.

In planning this undertaking, we are fortunate in having New York as the Convention City. It can truthfully be said today that

* Professor Walter is in the Department of Mechanical Engineering at Newark College of Engineering, and is Chairman of Publicity on the Local Committee for Arrangements for the S. P. E. E. Convention in New York next June.

no similar area on the face of this earth has as much to offer in the way of man-made structures as has this one. For the man, especially one with engineering interests, we have bridges, tunnels, towering buildings, enormous power plants and transportation systems, airports, sanitary works, parkways and libraries in abundance. For the ladies we have department stores, the exclusive Fifth Avenue shopping district, Broadway lighting at night, museums, and sight-seeing possibilities which are not rivaled anywhere. An effort is being made to work out a schedule of meetings which will permit our guests to take advantage of the New York area for sight-seeing as a part of their trip east. Accordingly it is suggested that as many as possible plan to arrive a few days earlier than the start of the meetings and participate in the scheduled sight-seeing tours on Sunday preceding the opening day. This will also assure members of plenty of time for any private trips which they may care to make to the surrounding area. This suggestion is particularly stressed in view of the fact that room facilities at Columbia University will be available at reasonable cost for the early guests, but cannot be used after the close of the meetings because of Columbia's Summer Session, which begins on July 2nd.

It is well to emphasize that the host institutions are particularly anxious that you plan to visit them while you are in New York. The educational facilities in this metropolis are both large and varied. In well under one hour's traveling time one can see a complete engineering institution housed within one building on a crowded city street or ivy-clad buildings dating back to pioneer days. All of the Metropolitan engineering schools are within easy access of the Convention headquarters and invite your visit. A fuller description of the participating schools will appear in subsequent issues of the JOURNAL.

Many of the details of the meetings have not as yet been worked out, but the general features of the program are already taking shape. Accordingly, we will turn our attention to announcements which can be made with reasonable assurance at this early date.

The general policies and arrangements of the meeting are being handled by both the Metropolitan Engineering College Administrators and a General Committee consisting of representatives of each of the participating institutions. The membership of these committees is as follows:

ADVISORY COMMITTEE

Joseph W. Barker, Dean of the School of Engineering, Columbia University.

George F. Bateman, Dean of the School of Engineering, Cooper Union.

Kenneth H. Condit, Dean of the School of Engineering, Princeton University.
Arthur L. Cook, Director of the School of Science and Technology, Pratt Institute.
Allan R. Cullimore, President of the Newark College of Engineering.
Parker H. Dagget, Dean of the College of Engineering, Rutgers University.
Harvey N. Davis, President of the Stevens Institute of Technology.
Brother Amandus Leo, Dean of the School of Engineering, Manhattan College.
Albert B. Newman, Dean of the School of Technology, College of the City of New York.
Rear Admiral George H. Rock, Webb Institute of Naval Architecture.
Harry S. Rogers, President of the Polytechnic Institute of Brooklyn.
Thorndike Saville, Dean of the College of Engineering, New York University.

GENERAL COMMITTEE

Professor James M. Church of Columbia University, General Chairman.
Mrs. John Rackliffe, Committee Secretary.
Mr. C. P. Miller of Columbia University, Treasurer.
Professor Lyman J. Ballard of Webb Institute of Naval Architecture.
Professor Clifford C. Carr of Pratt Institute.
Dean Franklin D. Furman of Stevens Institute of Technology.
Dean Eric Hausmann of the Polytechnic Institute of Brooklyn.
Professor Harold W. Merritt of Cooper Union.
Professor Frank C. Mirgain of Rutgers University.
Professor William Rose of New York University.
Professor Stephen J. Tracy of the College of the City of New York.
Professor Harold E. Walter of Newark College of Engineering.
Professor Robert Weil of Manhattan College.
Mr. Roy Heffner and Mr. Russell Deller of the Bell Telephone Laboratories—representatives of Industry.
Princeton representative (as yet undesignated).

Communications to the Central Committee should be addressed to Professor James M. Church, General Chairman, 366 Chandler Hall, Columbia University, New York City.

Headquarters.—Most of the sessions and events, exclusive of trips, will be held at Columbia University, 116th Street and Broadway, New York City. The last day's session, Thursday July 2nd, will be especially devoted to trips to the other participating institutions in Greater New York for group conferences and inspection of

the laboratories. Columbia University has offered its full facilities in the way of meeting rooms, lecture halls, dormitories, Men's and Women's Faculty Clubs, to the attending members, their families and guests of the Convention. The Headquarters for the National Officers will be located in Earl Hall, while the Local Committee prior to the meetings will be centered in Room 366, Chandler Hall, telephone UNiversity 4-3200.

Accommodations.—On the Columbia University campus the Men's and Women's Residence Halls will be opened for Convention use. Reservations at a low cost may be arranged for either single rooms or for two or three adjoining rooms. Each room is equipped with running water, and the toilet-shower facilities are conveniently located on alternate floors for men and women. Provisions will be made for daily change of towels, bed linen, etc., so that we will really have hotel service in a dormitory setting. For those who wish hotel accommodations, we offer Butler Hall, an apartment hotel adjoining Columbia's campus where small suites for families are available at a reasonable price. In later announcements downtown hotel rates will be listed, together with the traveling facilities between these hotels and the meeting places. The King's Crown Hotel near the center of Columbia University has been reserved as living quarters for the Council Members and National Officers and their families.

Meals.—A large number of highly desirable eating places, including the cafeteria and dining halls, Men's and Women's Faculty Clubs of Columbia, King's Crown Hotel, Butler Hall, and many nearby restaurants, are available for group and individual meals.

Parking.—An effort is being made to provide adequate free parking facilities convenient to the meeting for those who plan to drive. The parking problem in congested metropolitan streets, especially over-night, offers some difficulty. However, we are sure of being able to offer space in nearby commercial parking lots for as little as twenty-five cents per night.

Special Features.—The Convention will feature a Women's Program, with headquarters at the Women's Faculty Club, Columbia University. Additional special features will include Inspection Trips, Sightseeing Trips and Excursions, Special Entertainment, the Annual Banquet, Trips to Participating Institutions, etc., all in addition to the General Program, which is of course the real center of interest.

Your host institutions urge that you attend the Convention this summer. They are keenly aware of the possibilities for universal enjoyment which the Fiftieth Annual Meeting will afford. They will strive to make this meeting fully worth while. You should provide them with the opportunity to do so by attending.

NEW MEMBERS

ADAMS, DOUGLAS P., Instructor in Graphics, Massachusetts Institute of Technology, Cambridge, Mass. R. D. Douglas, E. F. Watts.

AMBERG, CHARLES R., Professor of Ceramic Engineering, New York State College of Ceramics, Alfred, N. Y. C. W. Merritt, R. M. Campbell.

BARRY, JOHN G., Instructor in Electrical Engineering, Princeton University, Princeton, N. J. J. C. Elgin, A. E. Vivell.

BATES, HERBERT T., Instructor in Chemical Engineering, Case School of Applied Science, Cleveland, Ohio. C. O. Miller, F. H. Vose.

BLUMENFELD, HARRY, Instructor in Chemical Engineering, Villanova College, Villanova, Pa. J. S. Morehouse, R. F. Banmiller.

BREWER, EVERETT L., Instructor in Chemistry, University of Maine, Orono, Me. Paul Cloke, A. S. Hill.

BRISTOL, RUTH A., Secretary-Librarian, Thayer School of Civil Engineering, Dartmouth College, Hanover, N. H. F. W. Garran, W. P. Kimball.

BROWN, WALTER F., Professor of Electrical Engineering, University of Toledo, Toledo, Ohio. Re-admission.

BRUST, ALVIN W., Assistant Professor of Civil Engineering, Washington University, St. Louis, Mo. A. S. Langsdorf, E. O. Sweetser.

CARPENTER, JAMES H., Instructor in Mechanical Engineering, Syracuse University, Syracuse, N. Y. L. B. Howe, E. F. Berry.

CHAMBERLAIN, MARGUERITE, Eastman Librarian, Massachusetts Institute of Technology, Cambridge, Mass. R. D. Douglas, A. L. Townsend.

CHEATHAM, JAMES O., Instructor in Mechanical Engineering, North Carolina State College, Raleigh, N. C. F. C. Brown, R. B. Rice.

CHURCH, JAMES M., Assistant Professor of Chemical Engineering, Columbia University, New York City. J. W. Barker, A. W. Hixson.

COLVIN, CHARLES H., Director, School of Aeronautics, New York University, New York City. Alexander Klemin, F. K. Teichmann.

COWGILL, ALLEN P., Assistant Professor of Applied Mathematics, Syracuse University, Syracuse, N. Y. Louis Mitchell, E. F. Berry.

CULVER, EDWARD G., Teacher of Drawing, 910 5th Avenue, Bay City, Mich. H. B. Dirks, L. S. Foltz.

DOUGLASS, IRWIN B., Assistant Professor of Chemistry, University of Maine, Orono, Me. Paul Cloke, C. A. Brautlecht.

ESSIGMANN, MARTIN W., Instructor in Electrical Engineering, Northeastern University, Boston, Mass. L. F. Cleveland, R. G. Porter.

FITCH, AUSTIN E., Assistant Professor of Architectural Construction, Washington University, St. Louis, Mo. A. S. Langsdorf, R. S. Glasgow.

FLANIGAN, ALAN E., Instructor in Mechanical Engineering, Illinois Institute of Technology, Chicago, Ill. J. S. Kozacka, H. L. Nachman.

FRECHETTE, H. A. VAN DERCK, Assistant Instructor in Ceramic Engineering, New York State College of Ceramics, Alfred, N. Y. C. W. Merritt, R. M. Campbell.

GAFFNEY, BERNARD J., Instructor in Chemical Engineering, Michigan State College, East Lansing, Mich. C. C. DeWitt, H. B. Dirks.

GALL, WILLIAM R., Assistant Professor of Mechanical Engineering, University of Louisville, Louisville, Ky. W. B. Wendt, J. M. Roberts.

GARRAHAN, CHARLES J., Instructor in Electrical Engineering, Swarthmore College, Swarthmore, Pa. S. B. Lilly, J. D. McCrumm.

GAUDIN, ANTOINE M., Professor of Metallurgy, Massachusetts Institute of Technology, Cambridge, Mass. T. T. Read, E. L. Moreland.

GOODIER, JAMES N., Professor of Mechanics, Cornell University, Ithaca, N. Y. P. H. Black, G. E. Grantham.

HANSON, KARL P., Associate Professor of Mechanical Engineering, University of Connecticut, Storrs, Conn. A. G. Christie, J. H. Lampe.

HANSON, THOMAS C., Assistant Professor of Civil Engineering, University of Detroit, Detroit, Mich. W. P. Godfrey, L. R. Blakeslee.

HARNESS, GEORGE T., Assistant Professor of Electrical Engineering, Columbia University, New York City. A. D. Hinckley, W. A. Curry.

HART, SIMEON T., Professor of Administrative Engineering, Syracuse University, Syracuse, N. Y. L. B. Howe, E. F. Berry.

HENDERSON, D. E., Instructor in Industrial Engineering, North Carolina State College, Raleigh, N. C. H. B. Shaw, E. G. Hoefer.

HENRY, JOHN A., Instructor in Mechanical Engineering, University of Illinois, Urbana, Ill. J. C. Miles, P. E. Mohn.

HORN, CLIFFORD R., Assistant Professor of Geology and Petroleum Engineering, Texas Technological College, Lubbock, Tex. O. V. Adams, H. L. Kipp.

JEWELL, WILLIAM R., Instructor in Drawing and Machine Design, University of Colorado, Boulder, Colo. F. S. Bauer, W. O. Birk.

JOHNSON, BERTRAM C., Instructor in Engineering Drawing, Iowa State College, Ames, Iowa. M. S. Coover, O. A. Olson.

JONES, RICHARD W., Assistant Professor of Mathematics and Engineering Science, Central Y. M. C. A. College, Evanston, Ill. C. J. Cardin, W. H. Seegrist.

KENT, BENJAMIN C., Professor of Engineering Drafting, University of Maine, Orono, Maine. Re-admission.

KONOVE, CARL, Instructor in Mathematics, Newark College of Engineering, Newark, N. J. J. H. Fithian, F. D. Carvin.

KREYDICH, WALTER, Instructor in Electrical Engineering, North Dakota Agricultural College, Fargo, N. D. H. S. Rush, R. M. Dolve.

LANE, RUTH M., Librarian, Vail Library, Massachusetts Institute of Technology, Cambridge, Mass. C. E. Tucker, H. L. Hazen.

LAYTON, WILLIAM I., Instructor in Engineering and Mathematics, Amarillo Junior College, Amarillo, N. M. G. A. Whetstone, W. W. Graham.

LEHMANN, CHARLES H., Instructor in Mathematics, Cooper Union, New York City. F. L. Bishop, Nell McKenry.

LINDSEY, LOUIS, Professor of Applied Mathematics, Syracuse University, Syracuse, N. Y. L. B. Howe, E. F. Berry.

MABIE, HAMILTON H., Instructor in Industrial Engineering, Cornell University, Ithaca, N. Y. C. I. Millard, F. O. Ellenwood.

MALAKOFF, HOWARD L., Assistant Professor of Chemical Engineering, Oklahoma, A. & M. College, Stillwater, Okla. G. W. Whiteside, H. G. Thuesen.

MALLORY, DONALD D., Professor of Engineering, Valparaiso University, Valparaiso, Ind. H. W. Moody, G. H. Sechrist.

MCGEHEE, WILLIAM, Associate Professor and Head, Dept., Psychology, N. C. State College, Raleigh, N. C. J. W. Cell, B. R. Van Leer.

MILLER, FREDERIC H., Assistant Professor of Mathematics, Cooper Union, New York City. J. K. L. MacDonald, C. H. Lehmann.

MOEN, WALTER B., Instructor in Mechanical Engineering, Pratt Institute, Brooklyn, N. Y. J. W. Hunter, R. B. Dale.

MOHR, JOHN G., Graduate Instructor in Glass Technology, New York State College of Ceramics, Alfred, N. Y. C. W. Merritt, R. M. Campbell.

MORGAN, MILLETT G., Instructor in Power Engineering, Dartmouth College, Hanover, N. H. W. P. Kimball, F. W. Garran.

MOSS, HELEN J., Librarian, Engineering Library, Yale University, New Haven, Conn. S. W. Dudley, C. F. Scott.

MURPHY, NELSON F., Assistant Professor of Chemical Engineering, Syracuse University, Syracuse, N. Y. L. B. Howe, E. F. Berry.

NICHOLSON, NATALIE N., Librarian, Graduate School of Engineering, Harvard University, Cambridge, Mass. H. M. Westergaard, G. M. Fair.

NORWOOD, JOHN N., President, Alfred University, and New York State College of Ceramics, Alfred, N. Y. C. W. Merritt, R. M. Campbell.

O'CONNOR, GUSTAVUS R., Commander, United States Coast Guard Academy, New London, Conn. J. W. Barker, C. E. Dimick.

O'LEARY, ALLAN M., Instructor in General Engineering, University of Dayton, Dayton, Ohio. G. A. Hofmann, A. R. Weber.

OLER, CHARLES B., Instructor in Engineering, Swarthmore College, Swarthmore, Pa. S. B. Lilly, J. D. McCrumm.

O'ROURKE, CHARLES E., Professor of Structural Engineering, Cornell University, Ithaca, N. Y. (re-admission). P. H. Black, G. E. Grantham.

OTTO, LOUIS L., Instructor in Experimental Engineering, Cornell University, Ithaca, N. Y. P. H. Black, G. E. Grantham.

PECK, RALPH E., Assistant Professor of Chemical Engineering, Illinois Institute of Technology, Chicago, Ill. H. McCormack, R. C. Kintner.

POWERS, ALFRED R., Professor of Electrical Engineering, Clarkson College of Technology, Potsdam, N. Y. R. C. Hudson, L. H. Allison.

PRIESTER, GAYLE B., Instructor in Mechanical Engineering, Case School of Applied Science, Cleveland, Ohio. F. H. Vose, G. L. Tuve.

QUATTLEBAUM, ALEXANDER M., Assistant Professor of Civil Engineering, Clemson College, Clemson College, S. C. S. B. Earle, E. L. Clarke.

RHODES, FRED H., Director, School of Chemical Engineering, Johnson Professor of Industrial Chemistry, Cornell University, Ithaca, N. Y. W. N. Barnard, P. H. Black.

RIX, CLIFFORD N., Associate Professor of Mechanical Engineering, Michigan State College, East Lansing, Mich. H. B. Dirks, L. G. Miller.

ROBERTS, ERSKINE G., Assistant Professor of Mechanic Arts, Lincoln University, Jefferson City, Mo. H. A. Curtis, O. J. Ferguson.

ROSS, FREDERICK W., Professor of Geology, Alfred University, Alfred, N. Y. C. W. Merritt, R. M. Campbell.

SAMPSON, MARTIN W., Instructor in Administrative Engineering, Cornell University, Ithaca, N. Y. S. S. Garrett, F. O. Ellenwood.

SPAFFORD, W. F., Professor and Head, Dept. Economics, Business Administration and History, Rensselaer Polytechnic Institute, Troy, N. Y. F. L. Bishop, Nell McKenry.

STAINTON, ROBERT S., Assistant Professor of Industrial Engineering, Texas Technological College, Lubbock, Texas. O. A. St. Clair, O. V. Adams.

TAYLOR, FRANK M., Instructor in Civil Engineering, University of Maine, Orono, Me. W. S. Evans, Paul Cloke.

THOMPSON, JOSEPH T., Professor of Civil Engineering, The Johns Hopkins University, Baltimore, Md. A. G. Christie, W. B. Kouwenhoven.

TUTT, CHARLES L., Assistant Professor of Mechanical Engineering, Princeton University, Princeton, N. J. J. C. Elgin, A. E. Sorenson.

WALKUP, JOSEPH K., Professor and Head, Industrial Engineering Dept., University of Pittsburgh, Pittsburgh, Pa. F. L. Bishop, R. C. Gorham.

WARDLE, RALPH M., Instructor in English, Cornell University, Ithaca, N. Y. E. A. Tenney, C. C. Winding.

WATERMAN, HERBERT, Lecturer in Chemical Engineering, University of Southern California, Los Angeles, Calif. R. E. Vivian, P. S. Biegler.

WHITE, MYRA, Librarian, Northeastern University, Boston, Mass. W. C. White, E. E. Hoskins.

WICKERSHAM, ROBERT O., Assistant Professor of Aeronautical Engineering, The Pennsylvania State College, State College, Pa. J. S. Doolittle, L. W. Whitehead.

WILSON, NORMAN E., Instructor in Electrical Engineering, University of Maine, Orono, Maine. I. H. Prageman, A. S. Hill.

WITTIG, FREDERICK E., Instructor in Shop Practice, Pratt Institute, Brooklyn, N. Y. R. B. Dale, J. W. Burley.

ZBELL, SAMUEL P., Instructor in Mechanical Laboratory, Pratt Institute, Brooklyn, N. Y. C. C. Tyrrell, H. S. Cameron.

THE STUDENT'S RESPONSIBILITY *

By ROBERT E. DOHERTY

President, Carnegie Institute of Technology

One can hardly discuss the responsibilities of the student in a program of effective learning without at the same time implying those of the instructor. However, I shall undertake my half of the assignment—to discuss the student's share—and try to stay on my allotted ground. But in undertaking this may I remind you that what the student's responsibilities are depends upon what the total job is, and that on this question of what it is there is not universal agreement? Hence I shall first try to define what I conceive the total job to be in which I am to identify the student's responsibilities, and then proceed to that identification.

The first question, then, is what are the purposes of the educational program. Fortunately this much of the problem is definite, thanks to the leadership of S. P. E. E. in issuing last year its report on the Aims and Scope of Engineering Curricula. Incidentally, you will be interested to learn that this report has been endorsed by the Engineers' Council for Professional Development, an action which not only establishes the guiding principles of the Report as an appropriate basis for the design of programs in engineering education, but testifies also to the constructive leadership of this Society. To begin with, therefore, I adopt here the objectives stated in that Report.

I need not repeat them, because I assume that you are all familiar with them. Their implications, however, are worth elaborating; indeed, these implications determine the total job I am undertaking to define. The objectives imply two things: one, that there is a specified body of fundamental knowledge that *must be learned and understood;* the other, that something *must be done in the use*—the application—of that knowledge. They are aimed for the most part at active competence. For instance, you will remember in the statement of objectives such phrases as "think straight," "making approximations," "devising means," "deal with," "select," "make critical analyses," "organize thoughts." In other words, the student must not only *acquire* knowledge but also *use* it. I recall at this point A. N. Whitehead's statement which

* Presented at the meeting of the Allegheny Section, S. P. E. E., The Pennsylvania State College, November 14–15, 1941.

we can well adopt: "Education is the acquisition of the art of the utilization of knowledge." In other words, the primary *end* of education, and especially of professional education, is the effective utilization of knowledge, not the mere possession of it; and the primary *process* of education is the acquisition of the art of that utilization, and not merely the acquisition of the knowledge itself.

Then to simplify the problem further I would make two assumptions: (*a*) that in view of the large mass of knowledge which the student must, at best, crowd into his mind, no subject matter should be included that will not bear directly on some later activity in the course; (*b*) that the test of understanding of knowledge should be whether the student can apply it in constructive thinking, and not merely whether he can repeat the language or symbols in which it may be expressed. No one would argue, I take it, that there is any measurable value so far as the objectives of a program are concerned in memorizing subject matter that is not understood; nor even if it *is* understood, if it is not directly related to those objectives. Such information may be valuable for a radio quiz program, but not for the defined purposes of engineering education.

Thus I would summarize and further qualify the elements which define the total job in which we are to identify the student's responsibility: (1) a definite, specified body of knowledge to be learned and understood by the student, most carefully determined on the basis of its relative appropriateness both with respect to the objectives of the curriculum and with respect to the student's available time; (2) programs that will assist the student in acquiring and understanding and retaining this body of knowledge; and (3) programs that will assist the student in learning how to utilize that knowledge in achieving the objectives.

Now if that defines the total job to be done, what is the student's share of responsibility?

It is to assume the initiative in his education. This is of course a comprehensive responsibility involving a number of more specific respects in which he should take the initiative, and these I shall presently indicate. Incidentally, I am sure we would all agree that this is also a responsibility that is not as simply discharged as it is stated.

I know as clearly as you that merely telling the student that he should take the initiative will not motivate him to do so. He must *learn* to do this just as he learns to do anything else, but under such appropriate motivation and guidance as we can accord him. I think I am correct in saying that the student will learn anything effectively only to the extent that he desires to do so. An environment involving experiences that establish the desire to learn is as essential for learning to take initiative as for learning anything

else in college. If this is correct, then we may accordingly assume that such an environment will be provided.

Specifically in what, then, should the student take the initiative? Certainly, in the first place, he should understand what he is trying to do. He should obtain a clear view and grasp of the objectives of his curriculum and of the objectives of each course he takes in relation to the whole. Whatever he does, he should know why he is doing it. Whatever may be the subject matter he is studying at the moment, he should see its relationship to what he has studied or will study. In other words, he should see the relation of the parts to the whole, in subject matter as well as purpose. Otherwise learning is seriously hampered because organization is missing and hence its potential contribution to motivation is lost. There is little enough of motivation at best, especially in the early courses, and surely he should lose none of it that might be afforded by the satisfaction of knowing what he is about.

Incidentally, it is hardly possible for the student himself to take this responsibility if such purposes and relationships are not planned out and also clearly defined in the minds of his instructors.

Secondly, the student should see to it that he understands what he studies. It is essential not only that he understand the relationships to which I have just referred, but that he understand thoroughly the subject matter he studies. This, I acknowledge, seems a dry and wooden suggestion. It certainly is threadbare. But I dare say that it nevertheless centers around a most glaring and disgraceful aspect of collegiate education. That faculties should sponsor and students carry out the futile pastime of memorizing subject matter and formulas that are not understood merely to be able on the examination to set them down, or to do the arithmetic involved in the use of a formula, is one of the strange phenomena of modern education. My research on this point during the past decade has revealed only one explanation: namely, that there is a specified extent of ground to be covered, and if time were taken that is necessary for full understanding, the ground could not be covered by the majority of the class. That the temptation to skim the surface is almost overwhelming, I acknowledge. But as a consequence a large proportion of students are obliged always to be rushed, to cram on the run, naturally without understanding, in order to get a passing mark; and if they can retain the required amount of half-assimilated information long enough to reproduce it on the quiz, they pass. I believe you will agree that I have not greatly exaggerated this point.

In the matter of understanding what he studies the student has a better chance to begin at once to exercise responsibility because he has this guide: He usually knows whether he understands a

point or doesn't. He knows whether the new thought taps his own previous experience—in other words, whether it fastens on to something that is already in his mind and understood. Usually, however, he runs into the discouraging situation in which he must choose between serious alternatives—between superficiality and failure in the course. But again, in the situation we have assumed, and defined, this barbarous custom would not exist, and the student would be encouraged to take the responsibility for understanding what he studied.

And finally, he should assume responsibility for learning to *use* his knowledge, for achieving, with the guidance of the teacher, the competences specified in the objectives of his curriculum; in other words, for learning to use his head.

I think I can do no better in summarizing than to quote a paragraph from an address I made a year ago to the students of the Carnegie Institute of Technology under the title "Complacency in Confusion":

> So I urge you to take the initiative and learn to use your heads. In the first place, dig yourself out of confusion. Insist on understanding! Do away with superficiality! Stop memorizing words and formulas that you don't understand, merely for a grade. Don't go on cultivating a habit that will cripple your mind for the rest of your days—the habit of superficiality, the habit of accepting confusion as a normal state of mind, the habit of playing on words that carry no meaning. You know when you understand and when you don't; when you grasp a point that is clear and clean cut and when, instead, it is blurred and confused. With all the emphasis in me I repeat: insist on understanding! Then, under the guidance of the faculty in your regular class programs, but under your own initiative, you will be in a position to go forward more effectively with the acquisition of a genuine education gaged to the demands of the changing world in which you will live.

THE CARNEGIE STUDY OF THE LIBRARIES OF TECHNOLOGICAL COLLEGES

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The majority of college administrators and librarians are probably familiar in a general way with the history of the Advisory Group on Academic Libraries set up in 1928 under the chairmanship of Dr. William Warner Bishop, Librarian of the University of Michigan, by the Carnegie Corporation of New York.[1] The chief purpose of the Group has been to aid and advise the Corporation in its program of encouraging library development in the colleges of this country and some attention has also been given to Canadian colleges and to American sponsored colleges in the Near East. The Corporation has made possible the compilation of the undergraduate book lists edited by Shaw and Mohrhardt, the publication of numerous books in the college library field, such as those by Gerould, Works, Randall, and Branscomb, and the preparation of suggested standards for college libraries.

The chief effort of the Corporation in this field however has undoubtedly been the series of grants to the various types of college libraries for the purchase of books. Mr. Robert M. Lester, Secretary of the Corporation, has expressed the aims of the Advisory Group in this direction as follows: "A national distribution of recipients; a representative list of different types of colleges; aid to colleges where 'intellectual ferment' was in process; the development of the general resources of the library, as distinguishd from provision of extra copies of textbooks; the selection of a few widely scattered colleges already possessing excellent libraries, which by additional funds could round out their collections so as to be demonstration points." He adds "Naturally, the few selections made have called a disproportionate amount of attention to the colleges which were not selected. But it has never been the purpose of the Corporation to do other than to call attention to the possibility and advisability of library development in a given

[1] William Warner Bishop, "Carnegie Corporation and College Libraries" (New York: Carnegie Corporation of New York, 1938).

field. It has not tried to support development at all possible points."[2]

In turn the Advisory Group, under Dr. Bishop's direction, has studied the libraries of liberal arts colleges, junior colleges, teachers colleges, colleges for Negroes, and the smaller state colleges and universities. Recently it turned its attention to the independent technological colleges.

The studies conducted by the Group have all followed a similar pattern. The first step has been the compilation of as complete a list as possible of colleges of the type to be considered. The second step has consisted in the gathering from published data and confidential sources of as much information as is available concerning the institutions under consideration, with particular reference to their libraries.

In its study of technological colleges the Advisory Group decided at an early date to eliminate from consideration for the present those colleges of engineering which are divisions of large universities. Universities and the large land-grant colleges offer a subject for separate study.

It was also determined not to give further present consideration to the considerable number of institutions which have not yet won accreditation by any of the regional associations, such as the North Central or the New England Association of Colleges and Secondary Schools. The only exception here was a group of mechanics institutes which were thought to fall in a separate category.

For the most part the final list for further action consisted of independent institutions accredited by the Engineers' Council for Professional Development though a few institutions with only regional accreditation were retained on the list since they offered promise of attaining full accreditation in the not distant future or were important in their sections of the country. The final list covered some thirty institutions from New England to the Rocky Mountains and from the southeastern seaboard to the arid southwest. It includes several different types of institutions.

One group consists of the accredited independent mining schools, all in the Middle West or West, usually in small towns, sometimes located in isolated regions. They are fairly small institutions with modest incomes, all state supported. They have had to face a decline in important branches of the mining industry and some of them have met the situation by expanding their curricula to include other types of engineering and considerable liberal arts work.

In a very different situation are the technical institutes located

[2] Robert M. Lester, "Carnegie Corporation Aid to College Libraries," *College and Research Libraries, 1:* 72–83 (December, 1939).

in cities like New York, Chicago, Pittsburgh, and Philadelphia. Their chief problem is usually that of finding space for overwhelming numbers of students, particularly evening school students, in a few crowded buildings in a downtown location. Those considered in this study were all privately controlled and found it necessary to provide for very large enrollments on budgets which left little margin for anything but the most indispensable items. These technical or polytechnic institutes often contain schools and colleges covering fields like the fine arts, business administration, and home economics which have little relation to the courses in engineering. They have for the most part, as would be expected, larger libraries than the mining colleges but are handicapped by the prevailing lack of space, the increased demands made by an expanded curriculum, and by staffs insufficient to serve the very large number of students.

The mechanics institutes, previously referred to, have very similar problems. Those here considered were all founded before the Civil War, are located in the larger cities, such as New York, Rochester, Cincinnati, and Richmond, and are under private control. Like the technical institutes, they suffer from lack of space and have more students, predominately evening school students, than they can conveniently handle on their rather small budgets. They differ in serving a non-collegiate group at a somewhat lower level of instruction and they do not confer degrees. Their libraries are small for the most part and often tend to be neglected.

Mention has already been made of the very large technical colleges, usually of land-grant origin, with annual educational expenditures of over a million dollars. These institutions have problems akin to those of universities and do not fall within the province of the present study.

The military colleges with strong engineering departments have their own problems. Here the difficulty is usually not lack of space or lack of funds for books but the question of how the cadet is to find time to use the library, given his very heavy program of drills, classes, and laboratories, and the restrictions of military discipline.

A final group of colleges, privately controlled, is to be found for the most part in the smaller cities. They are institutions concentrating on an engineering program with a minimum of liberal arts work and they offer wide individual variations.

The above grouping is not all inclusive and some institutions inevitably escape any fixed classification but this summary should at least make clear what diverse types of institutions are included under the heading of technological colleges.

The information gathered regarding these colleges was of two types. That taken from the bulletins of the U. S. Office of Edu-

cation and from other published sources was mainly of a statistical nature, covering such items as the number of students and faculty, the expenditure for books and periodicals, et cetera.

Information of a more subjective nature was obtained from various authorities who had personal knowledge of the institution in question and were competent to express an opinion as to the character of the work being done there, and from data in the files of the Corporation itself, gathered variously over a period of thirty years.

Some of the statistical findings may be of interest here. Comparing the median figure for all independent technological colleges accredited by the E. C. P. D. with the similar ones for universities, small liberal arts colleges, and teachers colleges printed in the February, 1941 *Bulletin of the American Library Association*, it was found that universities had a median enrollment of 4,299, technological colleges, 868, teachers colleges, 803, and liberal arts colleges 642. Universities were found to spend a median $2,450,744 for educational purposes, technological colleges $448,030, teachers colleges $269,501, and liberal arts colleges $233,211. Universities had 345,533 volumes in their libraries, technological colleges 35,776, teachers colleges 32,391, and liberal arts colleges 16,674. So far it will be noted that the median technological college ranks ahead of its sister institution in the teachers college or liberal arts field. The showing with regard to the median expenditure for books, periodicals, and binding is less favorable. Universities spent $34,380, liberal arts colleges $5,320, technological colleges $4,273, and teachers colleges $3,127. The showing with respect to the per cent of the total institutional expenditure which is devoted to the purchase of books and periodicals is still less impressive. Liberal arts colleges spent 1.97 per cent, universities 1.4 per cent, teachers colleges 1.34 per cent, and technological colleges .785.

It is perhaps worth noting how the figures for the technological college group as a whole are affected by the inclusion of the few very large land-grant universities which fall into the technological classification. If these three or four land-grant colleges are omitted, the following changes are to be discerned: the median number of students falls from 868 to 846, the median expenditure for educational purposes falls from $448,030 to $395,513, the expenditure for books, periodicals, and binding from $4,273 to $3,775, the number of volumes in the library from 35,776 to 31,437, and the number of periodical subscriptions from 352 to 290. On the other hand the per cent of total income devoted to the purchase of books and periodicals rises from .785 to .91 since the large land-grant colleges, omitting non-educational expenditures, still as a group spend an unusually small percentage of their total income for books, periodicals, and binding.

The above median figures conceal an extremely wide range. For example, taking the complete list of independent institutions accredited by the E. C. P. D., the number of students enrolled varies from less than 100 to over 7,000, the total expenditure for educational purposes from about $120,000 to $4,500,000, the expenditure for books, periodicals, and binding from less than $1,000 to $25,000, the per cent of income devoted to the purchase of books from .2 to 3.6, the number of volumes in the library from around 6,000 to 340,000, and the number of periodical subscriptions from 70 to 1,600. Even with the removal of the large land-grant colleges from the list the range remains a very wide one: students—low 57, high 3,900; educational expenditure—low $117,000, high $1,750,000; expenditure for books—low $800, high $12,000; number of volumes in the library—low 6,000, high 147,000; and number of periodical subscriptions—low 70, high 640. The figures for the per cent expended on books and periodicals remains the same.

Interesting too are the individual variations, too detailed to consider here, which affect the rank of a particular college in the different categories.

After a consideration of the statistical data and the confidential information placed before it the Advisory Group recommended that visits be made by a librarian experienced in such work to between twenty-five and thirty independent technological institutions, though it was believed that the available funds would probably permit grants to not more than half that number.

The relatively small number of colleges to be visited (as compared with 184 in the junior college field for example) made it possible for one person to see and report on all the institutions on the list. This meant a saving of time, ensured a uniform point of view throughout the reports, and a broader basis for judgment than would have been possible if the assignment had been divided among several men.

Over a period of years the Advisory Group, under Dr. Bishop's direction, has developed a corps of young men experienced in visiting college libraries and has evolved simple but adequate methods by which in a short time they can secure for a given library a general picture having sufficient detail and validity to enable the Advisory Group to reach a decision as to the advisability of recommending to the Corporation a grant for the purchase of books.

It should be added that the Group in reaching a decision may rely to a large extent on the visitor's report but it has also at its disposal the information contained in the Corporation's extensive files and in addition the advice of consultants, widely informed in the field under consideration.

The visitor arms himself in advance with all the information that can be obtained from printed statistics, the college catalog, annual reports, and other available sources. He is interested in trying to discover the position the college holds in its community and region, its relationship to nearby institutions, and the probable economic future of the region. He is greatly interested in the financial support of the college, the sources of that support, and any apparent growth or decline.

He tries to ascertain the general standing of the college, the calibre of instruction and such facts regarding faculty and students as have relevancy to his purpose. He is particularly interested of course in everything that directly concerns the library itself.

Much of what he seeks can usually be found in print, including such obvious items as the number of the faculty, the chief departments of instruction, the number of students, the amount of graduate work offered, changes in college income and enrollment, information with regard to the library building, the number of the library staff, their professional training and length of service, and often useful data concerning the collection and the availability of other libraries.

Less tangible questions must wait until the visitor has had a chance actually to visit the institution in question. He first seeks in an interview with the president to find answers to his general queries with regard to the status and expectations of the college. The president can also supply information concerning the budget, prospective additions to the staff, the possibility of an expansion of the library's physical quarters, and similar information of a more or less confidential nature which it would be difficult to secure from other sources. It is always necessary of course to weigh carefully all information offered since officials eager to secure grants for their institutions are naturally optimistic and likely to be reticent with regard to unfavorable factors. Information picked up at neighboring institutions may be a corrective here if used with caution. Of primary importance is the president's attitude toward the library. Where this is negative, displaying little knowledge or interest, the library is not likely to flourish.

As time and circumstances permit the visitor talks with other administrative officials, with some of the faculty, particularly with those on the library committee, and with a few students, seeking always to determine just what part the library is playing in the college community.

The faculty attitude toward the library is of scarcely less importance than that of the president and the visitor tries to discover what efforts are being made by the faculty to encourage student reading and promote the use of the library. Without faculty co-

operation in this matter, any librarian faces a discouraging uphill fight.

Most of the visitor's time must of course be spent in the library itself, talking to the staff, trying to estimate the quality of the work done and the judgment displayed in book selection. The latter is of particular interest in this connection since it has always been the policy of the Corporation to allow colleges which have received grants for the purchase of books for general undergraduate reading complete freedom of choice in selection of such books. Another point of unusual importance is the shelf capacity of the library. Where the limit has been almost reached and there seems no probability that more space will be provided in the near future, a grant involving the purchase of many additional volumes scarcely seems advisable.

Other points on which the visitor tries to check include the professional calibre of the technical processes, the availability of book selection tools, provision for recreational reading, and the use being made of the library by faculty and students. The last point is of course of great importance. A library with an adequate book stock serves little purpose if it is rarely used. An able and energetic librarian can overcome many handicaps. Where one encounters weakness and bad judgment the chances are that a grant will accomplish little in the way of encouraging "intellectual ferment."

In examining the book collection in a limited period of time reliance must be placed on general observation aided by a sampling technique with particular attention to the reference collection, periodicals, and provision for recreational reading. Usually a list of the journal subscriptions can be obtained; sometimes the librarian has been enterprising enough to check the collection or parts of it against the various standard lists and has figures available. In looking over the library of a technological college such lists as those prepared by the Engineers' Council for Professional Development, by the American Institute of Chemical Engineers, by the regional accrediting bodies such as the North Central Association, the Shaw and Mohrhardt lists, the standard lists of reference books, and current lists of "the most important books of the year" can all be useful, with due consideration to the aims of the college and the limitations of the curriculum.

Some of the statistical data derived from visits to the libraries of nearly thirty independent technological colleges has already been referred to. It is obvious that with a group so diversified generalities can have but limited validity. A few points however may be made.

The independent technological colleges as a group seem to be holding their own in a difficult period and should profit from the greatly increased demand for technically trained men incident to the national defense program. They are doing excellent work with a serious minded and hard working group of students.

The library, making all due allowance for the distinctive character of the technological college, has on the whole been neglected. Very few independent technological colleges have library quarters which would be regarded as satisfactory elsewhere. Crowded shelves and insufficient space for readers and staff are often the rule. Few such colleges have separate library buildings.

Departmentalization has been pushed to the limit in many technological libraries, pushed so far in some cases that there is no central library worthy of the name. In too many instances, departmental libraries are housed in offices or classrooms, locked much of the time, with no supervision other than that available from busy faculty members or their secretaries. Records are often haphazardly kept with duplication of expensive items and frequent losses due to a lack of trained supervision and adequate central control.

A few small laboratory collections are thoroughly justifiable but a policy of scattering the resources of the library throughout the campus is wasteful of books funds, encourages an already too prevalent trend toward narrow specialization, and inevitably results in poor library service as far as the majority of the college population is concerned. Students in an institution with a library setup of this kind never have a chance to enjoy the resources of a real college library, covering many different fields of interest, comfortably housed and professionally administered by a competent staff.

The librarians of technological colleges are generally above the average in ability and alertness and certainly are hard working. Even the larger colleges of the type usually have staffs much too small to handle adequately the heavy burden of routine work and then give the kind of reference and readers' advisory service a student has the right to expect. Salaries are much too low, low even when compared to the levels prevailing in liberal arts institutions and teachers colleges.

Even the larger and stronger institutions usually have small budgets for the purchase of books and periodicals. One notes too many gaps in the files of essential journals, a lack of many standard reference works and a scarcity of material on the more recently developed phases of engineering. Most technological libraries make inadequate provision for reading in non-technical fields, encouraging a professional narrowness of outlook which it should be one of the chief functions of the library to combat.

Probably the most important factor in determining whether or not to recommend a college for a grant is the attitude of the president toward the library: his interest or neglect; his belief, backed up by acts, that the library is a vital part of the institution, or his belief, expressed or implied, that the library is a luxury to be attended to only after the more important services have been taken care of.

In this connection every college president would profit by acquainting himself with Dr. Harvie Branscomb's interesting and valuable volume "Teaching with Books" and particularly with that chapter "Some Responsibilities of the College President" in which Dr. Branscomb sums up as follows the responsibilities of a president toward the college library: "The college president is ultimately responsible for the conduct and character of the library. If he would secure the fullest educational returns from his college library there are three specific services which he must render it, besides providing adequate financial support. These are (*a*) to take the lead in clarifying in the minds of all concerned the kind of library program which the college wants, (*b*) to select the librarian qualified to direct that service, and (*c*) to see to it that in the organization of the college the librarian is not separated from, but rather is brought into vital relationship to, the educational program. In most colleges this will mean elevating the status of the librarian."[3]

Other factors are sometimes to be blamed—a fatal weakness in the librarian or outside factors affecting the life of the institution itself, but competent critics say that in the majority of cases the fault for deficient academic library service lies directly with the president of an institution who is either ignorant of what constitutes good library service or, more rarely, knowing from his own student experience the important part a good library can play in a college is yet unwilling to allocate the funds necessary for adequate collections of books, an increased staff, and suitable physical quarters. Librarians share this responsibility and need to engage in well directed missionary work.

As an example of effective missionary work of this type one may cite the library conference in Atlanta last spring, attended by the presidents of some thirty colleges for Negroes and by the supervisors of Negro education in the various Southern states, a conference sponsored by the Carnegie Corporation of New York and the Rockefeller Foundation. The speakers included some of the leading and wisest persons in the library world, and the theme ably driven home to the audience of administrators was the vital

[3] Harvie Branscomb, "Teaching with Books" (Chicago: American Library Association, 1940).

importance of supporting good library service in every educational institution worthy of the name.

We need to convince those in authority of the tremendous part books and reading play in the life of every civilized man and the inescapable obligation of the technological college to furnish not only the minimum supply of texts but also the more important monographs, reference sets, and journals, the obligation to make a generous provision for those cultural interests, aroused or dormant, which run the constant danger of being neglected in a technological college. We must reiterate the need for well-designed, pleasant, uncrowded library buildings, provision for a staff of adequate size, adequately compensated, enthusiastic and prepared to give a superior service in interpreting the collection, stimulating the use of the library, and making its many and varied services an essential part of the institution as an educational agency.

THE NEW CURRICULUM IN ELECTRICAL ENGINEERING AT LEHIGH UNIVERSITY

By L. V. BEWLEY

Lehigh University

Part I

Factors Affecting the Selection of a Curriculum

There are many factors which influence the adoption of a departmental curriculum. Some of these factors are independent of the institution; while others depend very much on the particular school. In the former category may be mentioned: the professional requirements of industry, the educational requirements of society, expectation of individual progress in industry and in society, probable fields of employment—initially and ultimately, and the diversified views of many people.

Among the factors which affect the type of curriculum at a particular institution are: the capabilities of the instructors, the capabilities of the students, the plant and facilities of the institution, opportunities provided in other departments, the number of students and the permissible maximum and minimum sizes of classes, and general policies of the school. A brief discussion of some of these items will serve to indicate their influence on the E. E. program at Lehigh.

Influence of Industry

The broad field of electrical engineering is divided into two main branches: power and communication; and each of these includes:

(*a*) General engineering of a moderate technical level, such as: testing, routine design, maintenance, construction, and operating; and which at one time or another is engaged in by practically all engineers; particularly during their first dozen or so years out of college.

(*b*) Engineering of a high technical nature, such as: research, development, and advanced design; but which probably is not encountered by more than, say, 25 per cent of all engineers.

(*c*) Engineering of a low technical level, but requiring a business background, such as: commercial and sales work, appraisals and valuations, cost analysis, and production planning; these are

probably of concern, at one time or another during their career, to 25 per cent of all engineers.

(*d*) Management and administration; based on executive ability, business principles, and a technical background; probably not encountered by more than 10 per cent of all engineers, and then only in the later stages of their careers.

A graduate may find employment, in the electrical field, in any of the following:

(1) With a manufacturer of electrical apparatus or equipment; where he may be engaged in testing, commercial design, development or advanced design, research, sales, production, factory processes, or some other activity.

(2) With a public utility; where he may be in the distribution, transmission, or generation division of operation; concerned with tests, measurements, operating records, maintenance, system loading, etc.; or in the engineering division concerned with system planning, design of stations, substations, and lines, and in some cases with construction; or in the commercial division concerned with sales, public relations, accounting, legal questions, etc.

(3) With a consulting engineering firm, where he may be in the engineering section concerned with the design of stations, substations, lines, also with investigations of system stability, operating economics, etc.; or in the valuation section, concerned with property appraisals; or in the construction section, concerned with the construction and installation of plants and equipment.

(4) With an electrified industry (or railroad) where he may be concerned with tests, measurements, maintenance, operation, specifications, and perhaps installation of equipment.

(5) Teaching.

When we consider in more detail the kind of problems which are encountered in the different branches of electrical engineering, we arrive at an estimate of the constituent courses which should be offered in an E. E. curriculum to provide the young engineer with the technical tools which he will need. These tools may be divided into three classes: *necessary, desirable,* and *special:* partial specifications of which are given in Table I. Now it may be taken as axiomatic that every graduate should be equipped with the necessary tools, and with just as many of the additional desired tools of his profession as can be treated adequately in a four year program. It is agreed that there is no time in this short period for the special tools. But here I take sharp issue with the definition of "specialization." It has become the fashion in many schools where the curriculum has remained essentially unchanged for a quarter of a century, to excuse their failure to modernize by raising the cry of "specialization!" whenever it is suggested that some of the new

TABLE I

Divisions of Electrical Engineering	Physical and Mathematical Tools		
	Necessary	Desirable	Special
I. Circuits	Faraday's Law Ampere's Law		Maxwell's Eqs. Lagrange's Eqs.
D.C.	Kirchhoff's Laws		Hamilton's Prin.
A.C.	Complex Numbers Fourier Series	Determinants Matrices	Vector Analysis Tensor Analysis
Transients	Differential Eqs.	Operational Calc. Theory of Func.	Fourier Integrals Bessel Func.
Long lines	Differential Eqs. Hyperbolic Func.	Sym. Comps.	Integral Eqs.
II. Fields	Coulombs Laws	Fourier Series	Potential Theory
Electric	Definitions of potential, gradient, flux, etc.	Theory of Func.	Harmonic Func.
Magnetic			Vector Analysis
Flow	Flux plotting		Tensor Analysis Maxwell's Eqs.
III. Apparatus	Diff. Eqs.	Operational Calc.	Tensor Analysis
Transformers	Fourier Series	Symmetrical Comps.	Analy. Dynamics
Machines		Heat Flow	Elasticity
Devices			
IV. Applications	Combinations from above	Combinations from above	Combinations from above

and powerful tools of today be included in the curriculum. Other institutions, seeking space for non-engineering hobbies, would relegate these modern methods to post graduate work. However, the bulk of these new and powerful methods of analysis have a wide field of application, offer an intellectual challenge to the student, and, when taught properly, are easily within the grasp of the seniors.

Take, for example, the long distance transmission of power. For many years most engineering colleges have offered a standard course (usually an elective) on the electrical and mechanical design of transmission lines; in which the line is regarded as a balanced circuit with E_1 at one end and E_2 (or something else) at the other. But it is no longer sufficient to regard transmission as simply as this. The line and the terminal apparatus must be protected from lightning and switching surges, and this calls for a working knowledge of traveling waves and high frequency transients. The circuit breakers and relays on that line must be selected on the basis of fault currents, and recovery voltages, and this necessitates a familiarity with symmetrical components. The characteristics of

the generator must be considered from the point of view of the static and transient stability of that line, and this requires an understanding of advanced synchronous machine theory. It cannot be argued that such things as symmetrical components, line transients, system stability, and advanced machine theory are "tricks of the trade to be learned on the job." Every progressive power engineer will encounter them wherever he turns, whether he be a machine designer, a consulting engineer, or an operating man. They are not just "applications of the fundamentals," but part and parcel of the fundamentals themselves And they are much easier to learn in college than out on the job.

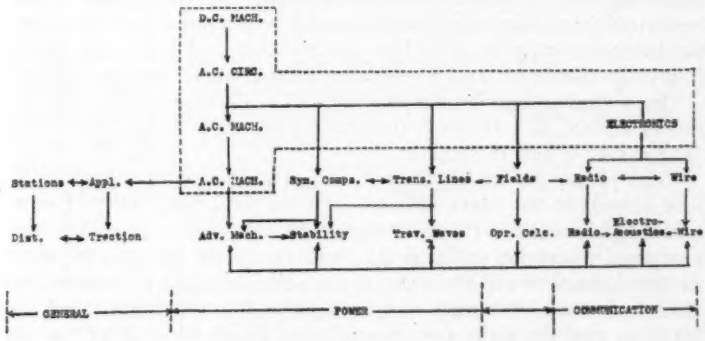

CHART I. Showing the coördination ties between courses (basic courses capitalized).

On the other hand, there are the many jobs in the power field where a high technical training (mathematics and theory) is of no particular value. The majority of the engineers with manufacturers of electrical apparatus are on standard design calculations, or in commercial applications, or in sales; all of which are of a more or less routine nature. Most of the engineers with public utilities are concerned with system economies, continuity of service, load distribution, and the like; and these problems are matters of general engineering judgment and experience rather than of higher theory. Engineers with electrified industries are, for the most part, interested in adapting appropriate drives to specific loads, writing specifications, installing equipment, and maintenance; and there is very little call here for more than a general engineering training. In consulting engineering firms, a considerable portion of the work is in making appraisals and valuations, or on construction; and here again it appears that a general engineering and business training is of greater value than advanced theory. Finally, in

managerial and administrative positions the emphasis is on the personnel, public relations, and business problems of an industrial organization; where a general engineering background is sufficient in order to make proper technical decisions after consultation with a technical staff.

At least three quarters of all electrical engineers are, sooner or later, going to fall into this *general engineering* category, where the technical level is moderate and where mathematics and advanced theory are seldom if ever used. However, very likely, many of them will start out on a higher technical plane before finding their natural level, and for this reason it appears feasible to educate about half of the power group along higher technical lines. This logical division not only recognizes the requirements of industry, but by segregating the technical and non-technical type of students it greatly facilitates and accelerates instruction to the two groups.

In a similar fashion the contents of a Communication Option can be arrived at. In short, the guiding principle should be "build the product to suit the market."

The young graduate will not, as a rule, be so fortunate as to find himself in the exact position, or even with the preferred company, of his choice. Circumstances may compel him to accept employment where he can find it; and throughout his career many diverse influences will force him along paths which he did not anticipate. (A man's training and inclination may be represented by a vector, and the strict requirements of the job by another vector, and the angle between is the power factor angle of his effort. Fortunate is he who can find a job which is in phase with his likes and capabilities!)

His progress will not, in the typical case, be spectacular—the road upward is long and hard. In college he may have decided (soon after he flunked some technical courses) that he was cut out to be an executive, instead of a mere technician; and to have prepared therefore by substituting wherever possible for the usual technical courses. This boy may be somewhat disappointed upon finding that he isn't vice-president in charge of something or other within a few years. In fact, a quarter of a century may elapse before he is faced with his first problem in corporation finance, and during that period his problems will be largely of a technical nature in competition with others who are better trained along technical lines.

A consideration of the above leads to the conclusion that *a modern curriculum in electrical engineering should offer major options in power and communication, with provisions for both the technical and non-technical type of student, and should be sufficiently versa-*

tile so that the graduate will not find himself at a great disadvantage if he does not land in the specific job for which he has in general prepared.

This requirement is ideally met by a curriculum in which the fundamentals common to all groups are taught in a *Basic* stem which, as late as possible, will branch out into three principal channels: *Power, Communications,* and *General.*

Social Humanistic Influence

During the past decade a great deal of pressure has been brought to bear on engineering schools to promote so-called "liberalization." What this comprises seems to come under four headings:

Scientific: (astronomy, geology, biology, psychology).
Social: (history, economics, sociology, government).
Cultural: (English composition, literature, languages, appreciation of the fine arts, philosophy).
Business: (public speaking, accounting, business law, corporation finance, statistical methods, business cycles).

To secure a *minimum* groundwork in all of these subjects, by incorporating the usual standard courses offered by the liberal arts and business colleges, would consume about 75 credit hours, or ½ of the total credit hours in a normal four-year curriculum; whereas the actual time available is of the order of ⅙ of the total. Of course, how far one department can go in this direction, in making up a new curriculum, must conform with the practice and policy of the school as a whole in this respect.

A moderate amount of liberalization along the humanistic-social—cultural stem is not only desirable: it is necessary. But an excessive leaning in this direction is necessarily at the expense of a sound foundation along technical lines. For perhaps a dozen years after graduation, the problems which confront the engineer are essentially technical. Promotions and advancement during this first quarter of a professional career depend, to a large extent, on his successful solution of technical problems. A student must first of all be equipped to take this initial hurdle. Long before he has achieved an executive position he will have had much leisure time in which to have prepared himself along the requisite non-technical lines; particularly if the college has given him a small, but well defined, start in that direction.

It appears that these conditions are best met, by requiring the students to take certain essential humanistic courses (such as English and Economics) and the adoption of a *General Study* plan.

Influence of the Institution

The capabilities of students during their first year or two in college depend to some extent on geographical location, and in a large measure on the level established by the entrance requirements. Later on, of course, the student capabilities are a reflection of the caliber of the teaching to which they have been subjected. The situation would be ideal if all students were equally ambitious, hard working, aggressive, and of a substantially equal high intellectual level. This, unfortunately, is far from the case. Perhaps one-third of the total may be classified as good students, one-third mediocre, and one-third poor. In a very large department these three groups could be segregated, and each group allowed to progress as fast as it is able. In a smaller department it is not economically feasible, from the point of view of school finances, to carry the segregation that far.

Nevertheless, it is desirable to segregate the lower third, particularly those who are "allergic" to mathematics, so that the progress of the others will not be retarded.

The capabilities of the instructors are of just as much importance in selecting a curriculum, as are those of the students. A Course may be profitably introduced which is off the beaten track, if there happens to be an authority on that subject on the staff. Certain Courses may be assigned to an instructor with the deliberate intention of whetting his interest and soliciting his enthusiasm. The capabilities and characteristics of each member of the staff must be studied and appreciated, so that each man is doing the job for which he is best qualified and where his efforts and experience count most. It is a waste of time to include courses for which there are not capable and qualified instructors. However, if the staff does not include a man capable of teaching an important fundamental course, then the sooner that staff is reinforced the better. Every staff should include at least one man who is familiar with the modern theories in the power field (advanced machine theory, symmetrical components, system stability, and transmission lines); at least one man on advanced theory (fields, operational calculus, transients, tensor analysis, Maxwell's equations, etc.); at least one man on advanced communication theory (networks, synthesis, radiation, etc.); and at least one man on the practice and economics of power (stations, distribution, industrial applications, electric traction, etc.).

A complete and fully equipped laboratory, which permits an adequate series of experiments to be conducted in synchronism with the class room work, is ideal. Many E. E. departments, operating on a small budget, have permitted too much of that budget

to be expended on rarely used toys for the staff, or filtered away on "research" projects which are of little real importance, with the result that they do not possess enough every-day apparatus to allow an intimate coördination between class and laboratory work. Yet such coördination is absolutely essential for maximum efficiency.

Courses offered by other departments of a university have a direct bearing on the design of a curriculum. For example, a course in heat transfer and fluid dynamics would be more valuable to the average electrical engineer than the time-honored courses in thermodynamics and hydraulics; yet if the former is not available in the college, it cannot be included in the curriculum. Many fine courses may be available in the Arts College which, in their extensive form, consume too many hours to find a place in the E. E. Program. To bring about changes of this nature is a slow process, since these changes concern outside departments.

General policies of the institution must be conformed with in arriving at a new curriculum. Some of these policies are matters of tradition. If physics were not attempted until after an adequate foundation in mathematics was secured, much greater progress could be made. If freshman chemistry were much curtailed it would not handicap the electrical engineer. But these and other examples are outside the jurisdiction of any one department. A school policy which arbitrarily dictates that an excessive part of the available time be dedicated to specific subjects may effectively choke the possibility of a department doing an adequate job.

Part II

The Lehigh Electrical Engineering Curriculum

A new undergraduate curriculum in electrical engineering, Table II, was tried out last year at Lehigh and is now in full effect. Its unique feature is the inclusion of many subjects, usually found only in graduate courses, but which nevertheless comprise part of the necessary equipment of the modern electrical engineer. This extension of content was made possible, without overburdening either the students or the staff, by close coördination, Chart I, between classroom and laboratory, lateral coördination between the courses of the same semester, and sequential coördination between courses in different semesters. This plan substitutes rigid organized options, built up of complementary courses, for the usual curriculum in which there is a rather free and wide choice of independent electives. The benefits are two-fold: (1) a curriculum worked out with care and study by an experienced staff is more likely to meet the needs of the profession than one determined to a large extent by the student, and (2) much more ground can be

TABLE II

First Semester		Year	Second Semester	
Chemistry and Lab.	(4)	Fresh.	Chemistry and Lab.	(4)
Engineering Drawing	(2)	(18/18)	Engineering Drawing	(2)
Algebra and Anal. Geom.	(3)		Anal. Geom. & Calc.	(3)
Mechanics	(4)		Physics (Mech. and Light.)	(4)
English	(3)		English	(3)
Military Science	(2)		Military Science	(2)
		Summer	Surveying	(4)
Economics	(3)	Soph.	Economics	(3)
Physics (Elec. and Mag.)	(4)	(18/18)	Physics (Dyn. and Heat)	(4)
Calculus	(3)		Calculus	(3)
Metallurgy	(3)		Direct Current Mach.	(4)
Fund. of Speech	(3)		D. C. Lab.	(2)
Military Science	(2)		Military Science	(2)
Electrical Meas.	(1)	Jr.	Electrical Meas.	(1)
A. C. Circuits and Lab.	(4)	(18/18)	A. C. Machines and Lab.	(5)
Advanced Calc.	(3)		Electronics	(3)
Mechanics of Mat. and Lab.	(4)		Hydraulics and Lab.	(3)
Heat Engines	(3)		Heat Engines	(3)
General Study	(3)		General Study	(3)
Engr. Lab.	(1)	Sen.	Engr. Lab.	(1)
Proseminar	(1)	(19/17)	Proseminar	(1)
A. C. Machines	(3)		Arts or Busi. Elec.	(3)
A. C. Machine Lab.	(2)			
Elec. and Mag. Fields	(3)	Power	Operational Calc.	(3)
Transmission Lines	(3)		Traveling Waves	(3)
Symmetrical Comps.	(3)		System Stability	(2)
Analytical Mech.	(3)		Advanced Mach. Theory	(3)
			Transients Lab.	(1)
Elec. and Mag. Fields	(3)	Comm.	Operational Calc.	(3)
Radio Comm.	(3)		Radio Comm.	(3)
Wire Comm.	(3)		Wire Comm.	(3)
Analytical Mech.	(3)		Electro-acoustic	(3)
Elec. Power Stations	(3)	Gen.	Distribution Systems	(3)
Industrial Applications	(3)		Electric Traction	(3)
Industrial Management	(3)		Industrial Management	(3)
Business Elective	(3)		Accounting	(3)

covered in a coördinated curriculum than in one left open to free electives.

The E. E. curriculum at Lehigh is designed for a normal senior class of about 30 students, which permits a sub-division during the senior year into Power, Communication and General Options.

These three options branch in the senior year from a main (Basic) stem which comprises those subjects which are common to all. The complete E. E. program thus consists of the following divisions (see Chart II):

Basic: foundation work in fields, circuits, electronics and machinery which are common to all branches of electrical engineering.

Communication: wire and radio communication, electro-acoustics, electric and magnetic fields, and transients.

Power: advanced machine theory, transmission lines, symmetrical components, system stability, electric and magnetic fields, and transients.

General: engineering and economic considerations in the design and operation of power stations, distribution systems, industrial applications, and electric traction.

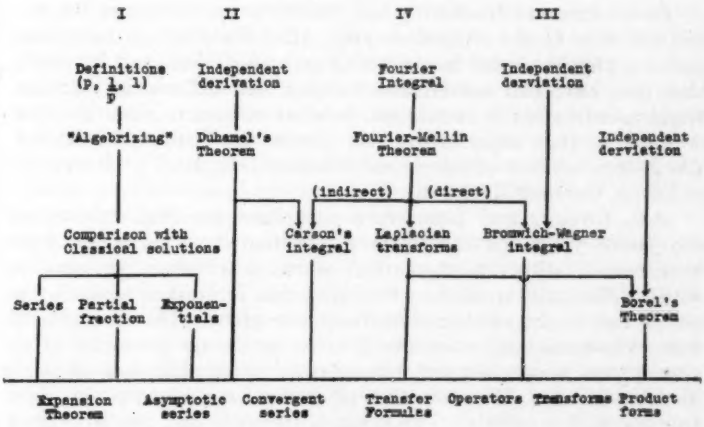

CHART II.

As a matter of fact, the Basic division devotes more time to electrical machinery than is strictly necessary for a communication engineer. Unfortunately, however, it is not always as easy to place graduates in the communication field as in power; and this situation is somewhat aggravated by the fact that a considerable number of Freshmen elect E. E. as their curriculum, because as boys they were intrigued by radio (a large percentage of them have been "ham operators"). In order, therefore, that a student specializing in communication may nevertheless find suitable employment in the power field, the *Basic* courses lean heavily to machinery.

Students do not make a final choice of their option until the beginning of the Senior Year. Nevertheless, those who know definitely that they are going to elect the Power Option, are encouraged to group together in one of the two duplicate classes of each Basic course, so that their training will mesh better with that which they will receive later on. This is particularly necessary for the Basic course in synchronous machines given in the first semester of the Senior Year. Here the desired segregation is brought about automatically by "conflicts" in the schedules, the power men taking one class and the communication and general men the other.

The Basic Courses

The Basic Courses, required of all E. E. students, are the essential foundation courses for all divisions. In chronological order, they comprise:

Direct Current Machinery and *Laboratory,* starting in the second semester of the sophomore year, after the students have completed a physics course in electricity and magnetism, and by which time they have had considerable integral and differential calculus. Rigid coördination is maintained between classroom work and laboratory, so that experiments and theory are kept synchronized. The general content of this course is that of Langsdorf's "Principles of Direct Current Machinery."

A.C. Circuits and *Laboratory* commence the first semester of the junior year, and the two are coördinated. This course runs concurrently with a mathematical course in advanced calculus, in which differential equations, Fourier series and other selected topics of use to the electrical engineer are given. By arrangement with this mathematical course, Fourier series are taken up at an appropriate time, followed immediately by applications to wave analysis in *A.C. Circuits* and laboratory experiments on wave analysis and synthesis. For these latter purposes, the laboratory is equipped with a harmonic motor-generator set consisting of 60, 180, 300, and 420 cycle generators on the same shaft. Both the excitation and phase angles on the harmonic generators can be varied independently. Thus the student can be assigned, for example, a triangular wave to analyze in class by both mathematical and graphical methods. He is then required to adjust the harmonic generator to yield this wave, and to confirm it by taking oscillograms (oscillograph technique is acquired at an early stage). This example is typical of the constant effort to make each course, even though in a different department, support and assist the work in subsequent or concurrent courses. The general content of A.C. Circuits is that of Kerchner and Corcoran's "Alternating Cur-

rent Circuits," except that no reference is made to symmetrical components, transmission lines, or simple transients; because these things constitute the subject matter of complete courses in the Power Option. Complex notation is developed directly from the circuit differential equations.

Electronics, in the second semester of the junior year, serves the double purpose of being an introductory course for the Communications Option and of giving basic instruction in electronics for the other two options. It covers vacuum tubes, mercury arc rectifiers, and industrial applications of electronic devices.

A.C. Machinery and *Laboratory* in the second semester of the junior year takes up transformers, polyphase and single phase induction motors. Langsdorf's "Principles of Alternating Current Machinery" is used as a text.

A.C. Machines and Laboratory in the first semester of the senior year is devoted to the study of synchronous machines and converters, paying particular attention to the harmonic analysis of armature reaction, permeance, and air gap flux; and to the two-reaction theory of machines in the steady state. Some time is given to A.C. commutator machines. This course is tied-in with the course in Field Theory in the Power Option, insofar as the free-hand plotting methods there developed are applied to flux plots of the interpolar, air gap, and tooth tip fluxes of machines, from which permeance curves are drawn and reactances computed. Langsdorf's "Principles of A.C. Machinery" is used as a test.

Proseminar, carried on throughout the senior year, provides excellent practice for the students in the preparation and presentation of technical papers. These papers are necessarily reviews of published material, or descriptions of existing plants; since it is not to be expected that original investigations can be carried out. Nevertheless, the caliber of some of these reports is surprisingly high. The work is judged by both the technical excellence of the written report, and the oral presentation. In their sophomore year all students are required to take a course in public speaking given by the English Department, and the principles there learned are applied in the proseminar. By suggesting proper subjects to the students, a certain amount of ground can be covered for which there is not time in the regular curriculum. For example: nomographs, skin effect, illumination, etc.

The Power Option

The *Power Option* was organized to meet the needs of the technical engineer, in accordance with the requirements of industry as set forth previously in this paper. The objective is to so equip

the student that, upon graduation he will be able to adapt himself readily to the technical problems of either machine design or system application.

Referring to Chart I, it is seen that the Power Option starts off with three coördinated courses which are an extension of A.C. circuit theory. These are Symmetrical Components, Transmission Lines, and Field Theory. A close liaison is maintained between these courses. Thus the magnetic and dielectric fields about cylindrical conductors are taken up in Field Theory as a prelude to the calculation of the inductance and capacitance of overhead conductors in Transmission, and the line constants so calculated are then available for the study of faults in Symmetrical Components. The same transmission line which is designed in one class is used for investigating system faults in the other class. In this way the student's time is conserved, as he doesn't have to calculate a new set of line constants, and he doesn't have to familiarize himself with a new circuit, before working out short circuit currents and unbalanced voltages. Furthermore, his interest is aroused by working with different aspects of the same system.

The *Transmission Lines* course covers the usual ground—calculation of inductance and capacitance for various arrangements of conductors, the long-line equations, circle diagrams, mechanical design, and economic considerations. No attempt is made to take up transients, faults, or stability, as these are handled in collateral courses. The general content of this course is typified by E. A. Loew's "Transmission of Power" with the exception noted above.

The *Symmetrical Components* course starts with the transformation of coördinates, sets up the condition equations for types of unbalance, establishes appropriate equivalent circuits, derives the sequence impedances of apparatus and circuits, and gives practice in the calculation of faults on systems. The general content is that of Evans and Wagner "Symmetrical Components."

The *Field Theory* course is based on the theory of functions of a complex variable, which serves the double purpose of providing a powerful tool for the study of fields, and as a means to its application in the course in operational calculus which follows the next semester. The work starts off by showing how fields are plotted from functions of a complex variable; such as the fields of simple sources or sinks, hyperbolic functions, powers of complex numbers, etc. Function theory is then developed through divergence, line integrals, Stoke's theorem (in two dimensions), etc. Rogowski's analysis of the fields and inductance of interleaved transformer coils is then given, making use of divergence and Stokes theorems. Herefrom the general laws of field plots are derived, and used to establish the rules for free-hand flux plotting. Free-hand plots

are made of the fields in the air gap and interpolar space of alternators, from which the reactances are computed, and used in the concurrent Basic Course on Synchronous Machines. The Schwarzian transformation is then studied, and the fields of parallel plates, armature slots, air foils, stream jets, grids, etc. are calculated (usually, to conserve time, only one equipotential and one line of force are actually calculated, and the rest of the field is then completed by free-hand plotting). Finally, function theory is carried forward to include Taylor and Laurent expansions, residues, and contour integrals.

In the second semester of the Power Option there are four coordinated courses: Advanced Machines, System Stability, Traveling Waves, and Operational Calculus.

Operational Calculus is a natural continuation of the course in Fields, since the function theory developed in the latter is directly applicable as the most powerful and rigorous method of studying operational calculus. However, in order to place the *mechanics* of the calculus in the hands of the student as quickly as possible, so that he can make immediate use of it in the courses on traveling waves and advanced machine theory, and also to familiarize him with the proceduce before he has to worry about rigor, the subject is taught in accordance with the plan shown in Chart II. First of all, the notation (unit junction, p, $1/p$ etc.) is given and interpretation based on the solutions of simple differential equations. "Algebrizing," after the fashion of Heaviside, then leads to the solution for convergent and divergent series, partial fractions, expansion theorem, etc. Applications are made to both lumped and distributed circuits, and much practice is obtained in the collateral courses in Traveling Waves and Machines. Duhamels' theorem is admitted in time to be used in the collateral courses. This historic treatment of the calculus takes up half the course. By that time the student is ready for a more rigorous development. The Carson integral is derived from Duhamels' theorem, and from it the series solutions, expansion theorem, etc. are obtained. Then the Bromwich-Wagner integral is independently derived from function theory and used as a means for obtaining the expansion theorem, asymptotic series, etc. Finally, the Fourier-Mellin theorem is derived and its conjugate parts (the direct and inverse Laplacian transforms) shown to be the previously encountered Carson and Bromwich-Wagner integrals. In this way the student is allowed to survey the whole field of operational calculus and to gain some insight into the different methods of approach. He learns how to use each method before he faces the final denouement.

Traveling Waves follows as a natural consequence to Transmission Lines. Lightning and switching surges, arcing grounds, and

the resulting high frequency transients in apparatus are studied. This is an ideal proving ground for operational calculus. Ground wires and lightning protection for the same line designed in the preceding semester are determined. The content of this course is that of Bewley's "Traveling Waves," supplemented by notes and A. I. E. E. papers.

Advanced Machine Theory continues the work in synchronous machines of the Basic Course, taking up theories of synchronous machines in the transient state. The A. I. E. E. papers by Doherty and Nickle, Park, Crary, Miller and others on the two-reaction theory of machines are used as text material. In this course, symmetrical components and operational calculus are made full use of.

System Stability is a natural follow-up for symmetrical components and the calculation of system faults. It is run in parallel with the Advanced Machine Theory. Thus machine characteristics can be calculated in one course and applied in the other. The course devotes most of its time to transient stability and the calculation of swing curves for different types of switching. It is too short to be comprehensive, but at least it gives the student an insight into the method of calculating stability, and practice with simple cases.

Transient Laboratory is for the purpose of giving some laboratory experience with all types of transients being studied—machines, system stability, traveling waves, etc. Both ordinary and cathode ray oscillographs and a new transient analyzer are used in this course.

Approximately a third of the E. E. seniors take the Power Option, and they are selected students who can do justice to the heavy load and requirements.

Three members of the staff are qualified to teach the material of this option; and each has had practical experience in the power field.

The General Option

The General Option has a two-fold purpose: (1) to offer training in the business, economic and general engineering features of power systems and industrial applications, and (2) to provide a less technical program for those whose interests and aptitudes are not along mathematical and theoretical lines. This latter provision permits the segregation of different types of students, and results in faster progress in all groups.

The General Option, as shown on Chart I and Table II, consists of four coördinated senior E. E. subjects; and courses in Industrial Management, Accounting, and business electives.

Electric Power Stations, given in the first semester, is concerned

with the elements of station design and operation, as influenced by both engineering and economical factors. Steam and hydro plants are studied, and appropriate equipment selected for different layouts.

Industrial Application runs concurrently. This course is essentially a study of the power requirements of all kinds of different loads—hoists, pumps, steel rolls, etc.—and the selection of appropriate drives from a knowledge of motor characteristics. Power factor correction, electrolytic processes, industrial control, factory illumination, etc. are included.

Distribution Systems, following in the second semester as a continuation of Power Stations, takes up substation layouts, feeder networks, economics of distribution, and operating practice. System short-circuits are considered, but not from the point of view of symmetrical components.

Electric Transportation is, in a sense, a continuation of Industrial Application. The course covers the usual ground: substations, distribution, locomotives, operating schedules, etc.

Coördination between the four courses of this option takes the form of avoiding duplication. For example, the types and principles of circuit-breakers and relays, although of interest in all four courses, are studied in detail under Power Stations. And the kinds and characteristics of conversion apparatus (motor generator sets, mercury arc rectifiers, and synchronous converters), although used in distribution, electric railways and electrolytic processes, are emphasized chiefly under Electric Traction.

Two members of the staff are eminently fitted, by practical experience with public utilities and electrified industries, to teach the courses of this General Option. Courses of this kind can be made exceedingly interesting, by visits to neighboring plants. The instructive value of such visits is greatly augmented by requiring comprehensive reports from the students.

The Communication Option

This option provides technical training in both wire and radio communication and in electro-acoustics. It stems from the *Electronics* course of the Basic Division, and shares, with the Power Option, the courses in *Field Theory* and *Operational Calculus* previously described.

While there are two parallel courses in *Wire Communication* and *Radio Communication* (with associated laboratory) throughout the senior year; they are, as a matter of fact, closely meshed, so as to minimize duplication. At the beginning of the year, master schedules are prepared by the two instructors in coöperation; and while it is not intended that there will be no deviation from these

schedules; yet they ensure that material, common to both courses, will be completed in the one to which assigned, in time to be available for the companion course when needed.

Radio Communication includes high frequency currents, resonant circuits, oscillating circuits, amplification, detection, modulation, radiation and television.

Wire Communication includes the elementary theory of networks, bridge and coupled circuits, impedance matching, telephone circuits, transmission lines and cables, communication apparatus, repeaters, wave filters and corrective networks.

Electro-acoustics, given in the second semester, takes up the basic elements of sound generation, transmission, and reproduction by electrical means. A mathematics course in *Analytic Mechanics* required in the first semester, is an invaluable tool for the study of the vibrating systems encountered in electro-acoustics. Thus, *Electro-acoustics* is more or less a focal point for three other courses —radio and wire communication and analytic mechanics. This kind of coördination, which is a characteristic feature of the entire E. E. curriculum, pays many dividends in the amount of ground which can be covered adequately. There are no random independent courses—every course of any option is one gear in a train; they are meshed together for mutual assistance.

Two instructors teach the Communication Option. One emphasizes the physical and experimental; the other the mathematical and theoretical point of view, but both have had practical engineering experience.

Non-Electrical Courses

Subjects other than electrical included in the E. E. curriculum are shown in Table II. These are in three principal categories: Science, Allied Engineering, and Social-Humanistic. The selection is governed for the most part by the general policies of the engineering college. The freshman year is uniform for all engineers at Lehigh, and a large portion of the sophomore year is likewise standard.

The *Scienee* branch includes freshman chemistry, physics, and mathematics. A unique feature of the physics courses is the unusual amount of mathematics made use of. There is no question that much more ground can be covered, and more adequately, if full advantage is taken of the mathematical approach. Not only does this practice redound to the effectiveness of the physics department, but it also gives much needed application of mathematics at an early stage in the student's career. Mathematics is prescribed through Advanced Calculus for all E. E. students, as a working knowledge of differential equations is essential to elec-

trical engineering. The Power and Communications Option are required to take, in addition, a mathematics course in Analytic Mechanics.

The *Allied Engineering* branch includes drawing, surveying, metallurgy, mechanics of materials, materials testing laboratory, hydraulics, and heat engines; and, in the case of the General Option, industrial management. These are standard courses offered in their respective departments and were not designed specifically for E. E. students.

The *Social-Humanistic* content of the Curriculum is partly prescribed by school policy and partly by the E. E. Department. The general policy at Lehigh requires six hours of English composition, six hours of economics, and approximately ⅙ of the total time devoted to this phase of the engineer's education. This time has been allotted by the department as follows: 3 hours of public speaking, 6 hours of general study, and 3 hours of arts or business elective. From 3 to 6 hours additional time can be secured by substituting for technical courses, if the substitution appears justifiable in the individual case. The General Study program differs from a mere provision for electives, in that the time must be devoted to a coördinated plan of study in which the student has evinced a real interest and not dissipated by random selections. In consultation with his staff advisor, the student must select his general study program so as to broaden his viewpoint, and obtain a foundation for subsequent study on his own.

Conclusions

1. Engineering curricula should be designed to meet the needs of industry and of society, taking into account the probable kinds of work in which the graduate may be engaged, his expected progress, and his individual aptitudes and inclinations.

2. It is perfectly feasible to include in a normal four year curriculum in Electrical Engineering an adequate treatment of the more useful of the advanced methods which are generally found only in the graduate schools.

3. Rigid coördination of both a lateral and sequential nature, and careful planning of the contents of associated courses, are absolute necessities if the required ground is to be covered effectively.

THE PLACE OF THE TECHNICAL INSTITUTE GRADUATE IN INDUSTRY *

By ARTHUR L. COOK

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It has been stated in the S. P. E. E. report on technical institutes, and by certain individuals, that industry needs about three times as many men trained at the technical institute level as compared with graduate engineers. However, in spite of this, the fact remains that industry has not given proper recognition and encouragement to the technical institute type of training.

Before discussing directly the subject of this symposium, it is desired to review briefly the author's personal experience with the technical institute type of instruction as a result of over twenty-five years service at Pratt Institute. Although the statements made are based principally upon the author's personal experience, it is believed that they represent the experience of many others concerned with this type of education.

The status of the technical institute and of its graduates has been very well described by Dr. Parke R. Kolbe in his article entitled "Whither Technical Institutes" (Jour. of Eng. Education, Oct., 1935) and the conditions which he described are substantiated by the experience of Pratt Institute with the technical institute type of instruction.

We are all familiar with the fact that many schools, which at one time conducted full-time day courses of a non-degree type which may be characterized by the term "technical institute" have abandoned them and now have full-time day courses on the engineering college level, leading to the first degree in engineering. Pratt Institute, for many years conducted two-year, full-time day courses of a technical institute character with curricula in industrial mechanical engineering, industrial electrical engineering and industrial chemical engineering. However, for reasons which will appear later, Pratt Institute recently changed these curricula to conform to engineering college requirements, with four-year curricula in mechanical, electrical and chemical engineering, leading to the degree of Bachelor of Engineering and, in 1938, awarded the first degrees under the new program. The curricula established for this new program, which is strictly on a degree level,

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are arranged in a manner different from the usual college engineering type, with a terminal point at the end of the third year when all students who have completed these three years successfully are graduated with the Institute's certificate. These graduates may then apply for admission to the fourth year, completion of which makes the student eligible for award of the B.E. degree.

At the present time about 60 per cent of the three-year graduates enroll for the fourth year. The remainder secure industrial positions and a few return for the fourth year after having been employed for a year or two. In some instances, three-year graduates are not admitted to the fourth year because, in the opinion of the faculty, the applicants are not well adapted for the work of the fourth year and should secure employment instead.

The change in Pratt Institute's policy with regard to its courses was not due to any change of opinion as to the value of short intensive technological courses of an engineering type, but solely because of the greatly increased discrimination against graduates of these courses on the part of industrial concerns and others. Some of the main features of this discrimination will be mentioned.

For many years, Pratt Institute's two-year day graduates were able to secure satisfactory technical employment without any marked discrimination against them because of a lack of a degree. They were engaged in the same type of work as degree graduates and had an opportunity to advance as far as their ability permitted without any handicap from the lack of a degree. Many instances might be cited of these two-year graduates progressing to very responsible positions in large companies, both in the engineering and the executive fields. In the late 1920's, however, there was a noticeable tendency on the part of industry to place more emphasis upon the possession of a degree, and this was of course accentuated by the industrial depression of the 1930's and the scarcity of technical positions. More and more concerns established personnel departments for the selection and training of their young engineers, and these departments rather generally looked askance at any graduate of a technical school who lacked a degree. If non-degree graduates were hired, they were placed in positions which limited their future and it became very well known that only those employees with degrees would be given the opportunity to compete for the more responsible positions of an engineering or an executive character.

Furthermore, during these depression years, more and more graduates attempted to secure government and state positions under Civil Service regulations. Here, again, the non-degree graduate found himself definitely shut out from competition for many engineering positions which he was quite competent to fill, merely be-

cause he had not attended a "recognized school" which granted degrees. State Boards of Education would not "recognize" a school unless it was set up on a degree basis.

About this time also, the licensing by the state of professional engineers began to attain great importance, and it was soon recognized that graduates from a non-degree school would be seriously discriminated against if they desired to secure a professional engineer's license.

With all these handicaps to progress in the engineering field it was decided by Pratt Institute to discontinue its full-time day courses of the non-degree type and to establish degree-granting engineering courses, with, however, a terminal point at the end of the third year. As stated previously, the engineering school of Pratt Institute has been operating on this basis since 1938, when degrees were conferred for the first time. So far as the Institute's evening school is concerned, however, it is the present intention not to grant degrees nor to set up the instruction on a degree-credit basis, but to continue a technical institute type of instruction for which there seems to be a great need in the New York Metropolitan Area, since most of the evening courses available are on a degree basis.

The author is unable to make any constructive suggestions as to improvement of the status of the full-time day technical institute course, but he and his associates have been giving considerable attention recently to evening courses of this type, and the following suggestions are made with these courses in mind.

Standardized Curricula for Evening Technical Institute Courses

The S. P. E. E. report previously mentioned points out that instruction of the technical institute type covers a very wide field of technological endeavor with the vocational school for training the artisan as one boundary, and the engineering school for the professional engineer the other. With such a wide field available, it is only natural that the technical schools should develop a wide variety of courses, some not much above the trade school level and others approximating the engineering school type, although on a briefer and more objective pattern with greater emphasis upon shop, drawing and laboratory subjects. This wide variety of curricula is further differentiated by a wide range of entrance requirements and length of course so that it is not easy at present for a prospective employer to evaluate the training of a technical institute graduate. In the case of well-established institutions, local prestige may be built up and graduates may attain a fair degree of recognition from local industries, but for more general recognition, technical institute courses should conform reasonably well to a clearly

defined pattern if national recognition is to be attained. The following characteristics are suggested as essential to this recognition:

(1) The level of instruction should be near the upper boundary of the educational field of the technical institute, and should offer *engineering* courses paralleling the college courses in a more intensive and practical form.

(2) The length of the courses should be fairly uniform with a substantial number of credit-hours required for graduation.

(3) Requirements for admission as regards prerequisites, particularly with respect to mathematics, should be reasonably uniform.

(1) *Level of Instruction.*—In stating that the level of instruction for the non-degree engineering school should approach the boundary of the engineering college, it is not intended to depreciate the value of vocational instruction, nor to deny the need that industry has for highly skilled artisans. The vocational high schools, particularly the technical high schools, are assuming responsibility for this type of training which may well be left to them and attention centered upon the upper boundary of the technical institute field. The instruction should be more objective than that in the engineering college with a large proportion of the time devoted to work in shop, drawing room, and laboratory; which is correlated with an adequate amount of class-room instruction. It should be emphasized that this technical institute type of training requires more extensive facilities in shop and laboratory than are required for undergraduate engineering school instruction. The faculty should be composed of individuals who are sympathetic with the objectives of the course and the type of student which they are to instruct. They should have had at least two or three years of experience in industry, and should keep their industrial contacts alive while serving on the faculty of the school. As a rule evening technical courses would be operated in conjunction with a day school having a full-time faculty. The teaching staff of the evening school should be composed of members of the day faculty supplemented, if necessary, by part-time instructors hired from local industries. It is not considered advisable to operate an evening school entirely with part-time instructors.

(2) *Length of Course.*—If the non-degree courses are to have national recognition a reasonable agreement as to length of the course is important. In the case of evening courses there are limitations in this respect because the students will be individuals employed during the day time with only a limited amount of time available for study. It is suggested that a total of 1000 to 1200 hours in attendance at classes is about all the time which could be

required of the average individual. In addition to the class-hours specified, approximately an equal number of hours in home-work preparation should be required. It is considered that about 9 hours per week in attendance is the most that should be required. On this basis, with 36 weeks per year the time to complete a course would be three to four years. This is on the presumption that the student has the necessary prerequisite instruction in algebra and trigonometry.

(3) *Prerequisite Studies.*—It is not considered possible to require that evening students shall have been graduated from high school, although experience shows that a very large proportion have done so. It is believed desirable to require as a prerequisite for admission to the non-degree course, that the student shall have had training in elementary and intermediate algebra, plane geometry and plane trigonometry. To accommodate students who have not completed these subjects in high school, it would be necessary to have available classes in these subjects which the students may attend before being admitted to the course.

When a proposal for uniformity of curriculum is made there is a tendency to object because of fear of regimentation of the instruction. A certain amount of uniformity is essential, however, before any consideration of general recognition can be given. This is necessary so far as the employers are concerned in order that they may know what sort of instruction the graduates have received. One reason why personnel officers favor the degree graduate is undoubtedly due to the standardization of the product of the engineering school and the ease of evaluation of the instruction of an approved school. It should be possible to arrive at a reasonable conformity to a pattern and still permit individual differentiation to a limited extent to meet local conditions.

It is the belief of the author, that not much progress can be made with the question of proper recognition by industry of the non-degree technical graduate until a more uniform pattern for such courses has been developed and recognized by competent authorities. Probably these would be the State Education Department and the Engineers' Council for Professional Development. The question of the pattern to be used for this purpose might well be taken up as a project by the Section on Technical Institutes which is responsible for this Symposium. One way in which this might be started is to prepare a specification covering the essentials of a non-degree type of technical course. An example of such a specification is that prepared by the American Institute of Chemical Engineers as a guide to engineering schools contemplating application to E. C. P. D. for the accrediting of a chemical engineering curriculum.

WHAT IS EDUCATION IN AERONAUTICAL ENGINEERING? *

By ALEXANDER KLEMIN

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It is now some twenty-seven years since the first formal curriculum of instruction in aeronautical engineering was offered in the United States, so that there has been experience enough to answer the above question. Perhaps one way to answer the question is to classify the activities in which an aeronautical engineer may engage.

In the early days of aeronautics, technical education had the restricted purpose of training men in the design of aircraft. A little later aircraft engine design became of interest. As the art of aviation and its applications developed, other problems had to be met. At the present moment we may offer the following classification of activities for the aeronautical technician:

I. Design, construction of aircraft, both heavier-than-air and lighter-than-air.
II. Design, construction of aircraft engines.
III. Design and construction of aircraft instruments and accessories.
IV. Research or experimentation in the broad field of technical aeronautics.
V. Mass production of aircraft.
VI. Mass production of aircraft engines.
VII. Engineering connected with the construction or organization of airways, airports and scheduled airlines.
VIII. Engineering operation of scheduled airlines.

This classification cannot be considered complete since aviation constantly touches up more and more fields of activity. Thus aeronautical engineers may be called upon to undertake either alone or in collaboration with engineers in other branches quite extraordinary activities such as the construction of towers for parachute training, or the design of hoppers to spray the boll weevil with arsenic or the design of aerodromes to be located in mid-ocean.

It should also be confessed that such activities as listed above are not the exclusive preserve of the aeronautical engineer. A civil

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engineer might be far better qualified to design an airport than an aeronautical man, and an electrical engineer might be exceedingly useful in air transport work which involves radio communication and lighting as two of its most important elements.

A Broad Educational Basis

If the possible activities of an aeronautical engineer are as broad then his basic education should be equally broad. Of course such a remark applies to any branch of engineering, but perhaps more forcibly in aeronautics than in other branches of engineering. The writer has often had to interview freshmen or sophomores who complained that they had come to the Daniel Guggenheim School of Aeronautics to study aeronautics and that they had not even heard the word airplane mentioned. To such complainants an answer can be made readily. It is only a trade school which advertises that it will make a man an aeronautical engineer in one year that can be bold enough or brazen enough not to offer a broad basis for subsequent specialization. Aerodynamics is but a development of fluid mechanics which is a branch of physics. The control and stability of the airplane, the complex tail spin can only be understood by someone who has grasped theoretical mechanics. There is scarcely anything in advanced technical aeronautics which does not require a mathematical training for its apprehension, machine design, kinematics and hydraulics, certainly will be useful in the design of flap or landing gear retracting mechanisms. Thermodynamics and the internal combustion engine cannot be dispensed with in the study of aircraft engines. Problems in corrosion protection of the seaplane and in handling aluminum rivets demand some knowledge of chemistry and metallurgy. Aircraft Stress Analysis requires more knowledge of structural theory than the design of the largest bridge or office building. In the aircraft itself, in the engine, on the airway, in radio communication, electricity finds application always. Surely a sufficient case has been made out for at least three years of fundamental training in Mathematics, Sciences and Applied Science, before there is an attempt at specialization. Perhaps the easiest way to define these first three years is that they shall be almost identical with the first three years of a mechanical engineer who expects to practice a highly technical broad complex branch of engineering.

A Specialized Senior Year

A start in aeronautics should be made in the Junior Year with a course entitled, let us say, Fundamentals of Aerodynamics and Air-

plane Design, and one entitled, the Aircraft Power Plant perhaps. If a broad education is really the goal, nothing more of aeronautics can be crowded into the Junior year.

The summer between the Junior and the Senior year might well be utilized in gaining practical experience in factory or on the airline and in the Senior year almost complete specialization is fully justified. This year can well be devoted to such subjects as Aerodynamics, Theoretical and Experimental; Airplane Stability, Control and Performance, Stress Analysis; Airplane Design; Propeller Theory and Design; Aircraft Engines; Aircraft Materials and Shop Processes; Aircraft Instruments and Accessories; and Aeronautical Laboratory.

Whatever professional path a man may eventually follow, the above group of subjects should be regarded as a minimum foundation for an aeronautical technician.

Is Graduate Study Desirable?

Stephen Leacock has poked fun unmercifully at the undue length of years now devoted to study by our young men. There is much to justify his view that our young men are starting life too late. Also in the present emergency any young man who secures a Bachelor's Degree in Aeronautical Engineering in good standing is reasonably certain of a fair offer in the industry. For perhaps the first time in aviation history scouts from industry have visited the campuses of our great schools in an effort to secure men. In the emergency also young men have probably been justified in accepting posts immediately and in abandoning ideas of graduate study for the time being. But aeronautics is becoming so diversified and at the same time so complex and difficult that graduate study in more normal times is fully justified. In fact, graduate study is the only way in which to get a footing in certain branches of the aeronautical profession.

Diverse Lines of Graduate Study

Just as in the beginning of the article we attempted a classification of aeronautical engineering activities, so we shall attempt a classification of the possible lines of specialization in graduate study.

I. Research and Experimentation in the Airplane Field

It is the writer's definite opinion based on many years of contact with the industry that where an airplane factory is seeking a man for research and experimentation in the airplane field, or merely advanced technical work in the airplane field, it will definitely give

preference to a man who has completed at least one year's graduate study. Such preference is not due to the fact that practicing engineers have a regard for higher degrees or for any degrees for that matter. It is only in England that a man is also careful to write a long string of letters after his name. Another reason is that modern aeronautical technology is becoming exceedingly difficult and mathematical and a young man who has completed the four years leading to a bachelor's degree with excellent standing may yet be quite unable to master an advanced paper in the *Journal of the Aeronautical Sciences*, or a stiff Technical Report of the N. A. C. A., simply because he does not understand the language. Accordingly, for men who wish to engage in research, experimental or analytical work (as distinct from drafting office and design room practice), the following group of closely allied topics is recommended:

(*a*) Advanced Applied Mathematics or Differential Equations or Vector Analysis for general mental discipline. (*b*) Hydrodynamics and Advanced Aerodynamics. (*c*) Wind Tunnel Technique. (*d*) Dynamics of Aircraft. (*e*) Theory of Elasticity and Advanced Structural Analysis. (*f*) Theory of Vibration and Aircraft, Flutter and Vibration. (*g*) A thesis involving both analytical and experimental work in the wind tunnel or structural laboratory. (*h*) Possibly some special problems in airplane Design.

II. Aero Engine Theory and Design

In airplane factories, men who have received specific aeronautical training predominate. In aircraft engine factories, one is more apt to encounter mechanical engineers. The reason is that undergraduate students in our schools of aeronautical engineering are more likely to have their imagination fixed by the possibility of designing a Clipper or the world's fastest fighter than by participation in boosting the horse-power of a well accepted engine. Therefore, it is suggested that men who can supplement the specialized senior year, by a year's graduate work in aircraft engines will find an excellent market for their wares. The grouping of courses for such men would be somewhat as follows:

(*a*) Advanced Thermodynamics. (*b*) Aero Engine Design. (*c*) Theory of Vibration. (*d*) Engine Balance and Vibration. (*e*) Advanced Machine Design. (*f*) Compressor Design. (*g*) Metallurgy. (*h*) A thesis with experimental work if possible.

III. Air Transport Engineering

In the early days of American air transport; college graduates were regarded with suspicion and the best posts were allotted in-

discriminately to fliers. Now it has been generally accepted that an airline shall have an engineering department and that the men employed therein shall be engineers. Since Air Transport Engineers do not need a very high standard of mathematical attainment, specialization in air transport engineering or engineering operation can be readily undertaken in the senior year. But a student will be all the better off if he can add qualifications in air transport to a complete undergraduate curriculum in technical aeronautics. In the University training of men who are to work on the airlines, it is well to bear in mind that the air transport engineer should be a man of more extensive, but not so intensive a training as the airplane analyst or aerodynamicist. The air transport engineer should indeed have a solid background of aerodynamics and structure, but he must be educated to act as general consultant in many diverse fields and know at least something of the many fields of knowledge which enter into air transport. Experience has shown that an excellent combination of studies can be selected from the following:

(*a*) Air Line Organization and Operation. (*b*) Airport Selection, Design and Equipment. (*c*) Aircraft Lighting. (*d*) Electronics and Aircraft Radio Communication. (*e*) Meteorology, Theoretical and Practical. (*f*) Meteorology and Dispatching. (*g*) Traffic Control. (*h*) Performance Theory with special reference to air line operation. (*i*) Instruments. (*j*) Air Transport Plane Design. (*k*) Navigation. (*l*) Maintenance and Repair. (*m*) Accounting and Economics.

IV. Principles of Aircraft Production

For a number of years the writer has been of the opinion that sooner or later the emphasis in airplane manufacture would shift from experimentation to production as has long been the case in the automobile industry—where production men are now apt to be more highly remunerated than designers. Certainly even today, under the stress of war emergency, research and improvement are as important as ever. But would not our national defense effort have been greatly benefitted by an understanding of aircraft production? In many respects aircraft mass production, particularly for military or naval purposes is far more difficult than automobile production. Nobody expects an automobile manufacturer to introduce improvements once the production line has started. In military or naval aircraft quantity must be combined with an eye to superiority of equipment at any instant at the front. The vast aerial production of the Nazis was nullified in September 1940 be-

cause the British who had started later to arm had a slight superiority in fighter equipment. Also in aircraft production more refined methods and materials are probably necessary. The author has been assured by many practical men in the industry that there was room in it for college men who made the manufacture rather than the design of airplanes their aim.

In all probability a curriculum in Aircraft Production should be a matter of coöperation between a Department of Aeronautics, and a Department of Industrial or Administrative Engineering. The whole plan of instruction, even the names of the constituent courses remained to be explored. One of the serious difficulties would be that college teachers are not apt to be well versed in manufacturing methods, while practical production men are likely to be of the inarticulate type who prefer to do rather than teach.

V. Aircraft Instrumentation

Space will permit only the bare mention of this topic as a subject of graduate study. As instrumentation replaces human senses not only in aviation but in a hundred other industries, is it not logical to expect courses in scientific instrumentation or the like?

VI. Rotary Aircraft—Lighter-than-air

These two branches of aeronautics are linked together because they each might conceivably need special graduate curricula, and because for each of them there is doubt as to whether attention is justified or not. If a Department of Aeronautics is adventurous and ambitious in regard to its graduate offerings and wishes to undertake one or other of the above topics, then Rotary Aircraft would seem a better choice. Except for coastal patrol, balloon barrage, observation balloons, it is difficult to see a future in lighter-than-air craft. But if Rotary Aircraft should attain practicality it would have a very important sphere of its own in military aeronautics, and a popular priced versatile helicopter would mean popularization of private flying. Rotary Aircraft, also, provides a complexity of problems which can but benefit a graduate student, even if he subsequently engages in the more prosaic design of fixed wing air craft.

Conclusion

The above considerations indicate that there is vast scope for further effort in the field of aeronautical engineering and a number of new fields to develop, particularly in the graduate field.

TEACHING DYNAMICS *

By S. TIMOSHENKO

Professor of Theoretical and Applied Mechanics, Stanford University

Recent development in the manufacturing industries is characterized by the ever increasing use of scientific methods in solving engineering problems. Many problems which not long ago had to be treated on the basis of experience or solved by "rule of thumb" have now obtained rational scientific solutions. Such application of analysis is not limited to machine design problems but is extensively used also in developing improvements of various technological processes. For example, the successful application of welding has depended very much upon the work of research engineers who have carefully investigated the properties of weld metal, the fatigue strength of welded joints, and the residual stresses induced by nonuniform heating of the metal during welding.

The development of scientific methods of analysis of engineering problems and the rational use of such refined instruments as vibrographs, accelerometers, magnetic strain gauges, piezo-quartz devices, photoelastic equipment, etc., requires engineers with broad scientific knowledge in such fundamental subjects as mechanics and physics. Industry realizes the need of having engineers with a broad scientific training and is much interested at present in the question of a proper education of future engineers in the colleges.†

It seems generally accepted now that the engineering schools can not prepare real designers; this must be left to industry, but the schools can concentrate on the proper training of future engineers in the fundamental sciences which will facilitate their adaptation in industry to the trend towards a more intensive use of scientific methods in solving technical problems.

In every program for training future engineers in fundamental sciences, the place of engineering mechanics is one of the most important. Most of our engineering subjects are based on mechanics and a proper presentation of this subject to engineering students can not be over estimated. Keeping in mind the variety of me-

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† This can be seen in the activity of the Committee on Engineering Schools of the Engineers Council for Professional Development. See the report "Present Status and Trends of Engineering Education in the United States," 1939.

chanical problems with which the engineer can be confronted in his future activity, it seems preferable to give him at school the opportunity to become acquainted with as many general methods of attack as possible and to illustrate the application of these methods to practical engineering problems, but to avoid routine drill in the manipulation of standardized methods of solution. Such a broadening of the mechanics courses seems feasible only if the proper toools are used in the presentation of this subject. All engineering students have sufficient preparation in calculus and it seems only logical to use this knowledge of calculus in the mechanics courses and, in dynamics, to introduce also the notion of the differential equations of motion of a particle and of a rigid body. Only in this manner can students be shown that there exist general methods of attack on dynamics problems by using which they can express their problem in the form of a differential equation and so reduce it to a problem of calculus. Only by using the differential equation of motion can a proper treatment of important vibration problems be given so that students can understand the phenomenon of resonance and the basic theory of such instruments as the vibrograph and accelerometer now so widely used in industry. The use of the differential equation of motion facilitates also the establishment of the relation between various groups of problems in dynamics. If, for example, the student has some knowledge of rectilinear vibration of a particle, then the torsional vibration of a flywheel on a shaft can be easily treated since the differential equations in both cases are identical. In our courses of mechanics we are limited very much with time and only the very simplest problems can be treated. If in the discussion of these problems the students acquire some knowledge of the fundamental equations of dynamics, they will be better prepared for further study when in their future work they encounter more complicated problems and need to refer to books and papers of an advanced character. The preparation of students for such reading must be one of the principal aims of the engineering college training. Finally, the use of the differential equation of motion facilitates the introduction of such general principles of dynamics as D'Alembert's principle, the principle of momentum, and the principle of conservation of energy.

Naturally the presentation of the various principles of dynamics must be illustrated by engineering examples. The importance of a proper selection of problems can not be over emphasized. It is very desirable to take problems having a technical character. The discussion of problems of this kind usually gives the teacher a valuable opportunity to show to the students the logical methods of approach to the solution of engineering problems and to demonstrate the consecutive steps by which a complex technical problem

can be finally brought to such a state of idealization that it can be expressed mathematically. In his future activity the engineer always will be confronted by complex problems, the mathematical formulation of which becomes possible only after various simplifications and reductions. It seems logical to give students sufficient exercise in acquiring skill in making the simplifications in such a way that the principal characteristics of the problem are retained.

The selection of mechanical problems having engineering interest has also a great pedagogical importance. Usually only a few of the students in the class will be interested in purely mathematical or geometrical problems. The interest of a majority can be attracted to the problem having an engineering flavor.

Problems of a technical character also have the advantage that frequently they give to the teacher the opportunity of making interpretation of the results of the mathematical solution, and their technical significance. Such discussions may be of primary importance if we keep in mind that mechanics is one of the first subjects in which our students encounter the application of theory in the solution of engineering problems.

It seems very desirable to insist that students prepare the solutions of their problems first in algebraic form since this form gives the chance of verifying the answer by "dimensional check." Another advantage of the algebraic solution is that it greatly enriches the possibilities of interpreting the results and explaining their practical significance. The algebraic form of solution is preferable also if proper attention is to be given to numerical calculations. Only by having the solution in algebraic form can it be seen with what number of figures any intermediate calculation must be made in order to obtain the desired degree of accuracy in the final results.

The programs of our engineering schools are usually so crowded that there is not much possibility of expanding the undergraduate courses of engineering mechanics. It seems then that further development in teaching dynamics can only be accomplished by introducing graduate or elective courses in that field. Some engineering schools are already following this plan and we find in the university catalogues such courses as theory of vibration, advanced dynamics, aerodynamics, and hydrodynamics. The development of such advanced courses in dynamics is of great practical importance since only in this way can research engineers for that field of engineering be prepared. The need for such engineers is clearly demonstrated by the fact that some leading manufacturing companies at present are spending considerable time and money to properly prepare engineers for research work in the field of engineering mechanics.*

* For example, the Westinghouse Electric & Manufacturing Company, Pittsburgh, Pennsylvania.

The development of graduate courses in engineering mechanics may be helpful also in improving the undergraduate teaching of mechanics since by these courses the teaching staff in mechanics can be gradually built up. We are of the opinion that the teaching of undergraduate courses can be successful only if it is done by teachers with a broad knowledge of mechanics who can always bring to the students' attention numerous applications of their science in various fields of engineering. It is very important for a teacher to be himself a research engineer. It seems that those men who are themselves participating in the development of the science have a better chance to inspire student interest than the men who are only teachers.

In conclusion, I would like to state that the success of the courses in mechanics depends very much on their close connection with the various engineering courses using mechanics as their basic science. If, for example, a teacher in machine design does not limit himself to the application of the accepted formulas but reviews with his students also the derivation of these formulas, he will not only make his subject more interesting but will also develop in his students the precious attitude of a critical consideration of the formulas which they are using and the inclination for a scientific analysis of their problems. Such an analysis will usually show to the student that all the variety of formulas and requirements in design are finally based on only a few fundamental principles of mechanics.

To establish such a contact between the courses of mechanics and the engineering courses which depend upon them, it seems very desirable to have at least some teachers of engineering subjects participate also in teaching mechanics. For example, some teachers of machine design should participate in teaching dynamics while some teachers of theory of structures may participate in teaching statics and strength of materials. Such coöperation will be very profitable for both sides. The teachers of engineering subjects will bring to the mechanics courses many interesting problems from their practical experience. At the same time they will become acquainted with the students' work in the fundamental science of mechanics and will use this science to a greater extent in their engineering courses.

The opinion of the author is that only on the basis of such cooperation in teaching can a satisfactory preparation of students in the field of fundamental sciences and engineering sciences be attained.

RESPONSIBILITY OF THE ENGINEERING COLLEGE FOR PRESENT CHAOS IN INDUSTRIAL RELATIONS *

By T. W. PRIOR

Goodyear Tire and Rubber Company

It goes without saying that all the responsibility of the present chaos in industrial relations does not lie with the engineering college or the engineering men in industry. However, a large portion of the responsibility does fall on the engineer, and in turn upon the engineering college.

What is the cause of our labor chaos? Forgetting technicalities, it is the inability of the management and labor to come to a mutual understanding of what is fair and square. Let us take a look at the background of this group. The laboring man has a limited educational background, and seldom if ever, is he technically trained. The manufacturing management as a group are well educated, and many of them are technically trained, with the percentage of technically trained men increasing continually.

Of the men coming out of our universities trained in Liberal Arts, Business and Engineering, the Liberal Arts and Business people are absorbed in sales, business operation and accounting generally—whereas the manufacturing requirements are largely filled by engineers. This means that the engineer is the one who is coming in contact with the worker; whether his function be one of staff or one of direct production supervision, he is the one who has to deal with the working man, as well as establish the company's policies which govern the worker, and today he spends considerable of his time in handling the differences between the laborer and management. This automatically lays the responsibility as a group for the management side on the engineer, and in turn may be laid at the door of the engineering schools.

Are the engineering students prepared to accept this responsibility? I think most of us will agree that they are adequately prepared technically, but are they prepared to deal with the problems of labor relations? Few of the so-called technical jobs in industry are highly technical. Most of the beginner engineering jobs require only the fundamentals of engineering. In addition to these

* Presented at the 49th Annual Meeting, S. P. E. E., University of Michigan, June 23–27, 1941.

fundamentals the individual must exercise horse-sense and be able to exchange ideas with his fellow workers.

This year while interviewing a senior engineer I asked him "Wherein do you think the engineering students are not prepared adequately for industry?" I felt his answer was worthy of comment. "We are taught to approach each problem logically but not psychologically." Unfortunately he is going to find in industry that the boss as well as the man he is working with do not always react logically.

What is industry looking for in the young technical man? What do the various recruiting men, who come to the campus, look for? You will find on asking them, they have many yard sticks, but in general I believe I am safe in saying a well-rounded individual who has adequate training in the technical fundamentals, a personality which indicates that he will be a good man to do business with, and a sense of direction or desire for the type of work for which he is best prepared. This means that we consider three major things:

1. Is he adequately prepared in the fundamentals of engineering in his field?
2. Has his personality been developed to the point wherein we can see possibilities in the organization for him as a business man, and a man with whom we would like to work?
3. Has his training in school, plus his own personal makeup developed a desire to do the type of work for which he is best prepared? Is he positive along these lines or negative?

Let's briefly cover these three items:

1. *Technical Preparation.*—With the exception of technical research men who should be given their advanced technical training in graduate schools, all that we expect to get in the young engineer, who is graduating with a bachelor degree, are the fundamentals of engineering and, I believe, many of we people in the industrial field feel that you are going beyond this particular requirement in many cases.
2. *Personal Development.*—Here I find quite a difference of opinion. Many believe that the engineering schools do not have time to include many courses on personal development in their curriculum, and that this phase of the individual development should be left to extra-curriculum activities.

   Personally I do not agree, for I feel that too many engineers in their extra-curriculum life confine their activities to association within the engineering groups—whereas they should be working with members of the other colleges. Extra-curriculum

activities without a question do help to develop the individual. However, there are many of the actual technics which are not brought out in these activities, and if this particular angle of the individual is of such importance to the employer, certainly more formal instruction should be included along this line.

Inasmuch as the engineer is going to deal with non-technical men as well as technical men, he should be encouraged to associate with Liberal Arts and Business students in activities and classes.

3. *Direction and Desire.*—If a satisfactory job has been done on the first two items, the third item will have been pretty well developed, if augmented by a four-year program of vocational guidance in which considerable stress is given as to what is actually to be expected in the industrial field after graduation, the boy should develop a positive sense of direction or desire. Along this line, I might say that we in our organization feel that more should be written along the lines of the Yale Publication in 1932, written by Stewart & Clements, "The Choice of an Occupation."

Let's go back to item two, for this is the section in which I believe the engineering colleges could do more than they are doing. What courses are to be taught along the line of personal development? This would open a lengthy discussion, which would probably take more time than this complete discussion. However, there are a few suggestions which I would like to make.

I believe it is advisable to have your students take courses in the field of personal development in the Liberal Arts and Business Schools, for this brings them into association with the non-technical groups and gives them an opportunity to approach the subject from a non-technical angle as well as to enter into activities with other colleges in the university.

How is he going to express his ideas to those with whom he works? Either through the spoken or written word—but it is a recognized fact that most engineers are poor public speakers and report writers.

Much has been said about the courses in industrial relations. I can think of no better course for engineers, if the subject is approached from a study of labor relations, as a tool to use in whatever part of the organization the young engineer may find himself. Help him realize that it is one of the biggest tools used by the man in production supervision, time-study work, design work or any other technical activity.

Too many boys look upon the personnel department as a large organization, whereas it is in most organizations a small group, and the personnel function from an operating standpoint is largely designated to the supervision.

Industrial organization and management, also, has a place in this type of program, for it assists in the vocation guidance program as you deal in actual opportunities in the industrial organization, what does the young engineer have to look forward to?

He, also, needs an understanding of the non-technical organization, for he will have to understand this function, and the work these people do in the company.

There are many other suggestions along the line of psychology, English, etc., which could be covered and with which you are all familiar, but do not need to be discussed as a part of this program as it could be determined by each school and is not a part of this discussion.

In what proportion do we consider the three factors in selection? No percentage could be perfect, but as a rule in my own case I feel I divide these three factors into the following proportions in considering a bachelor's man:

40%—for his training or equipment in his field
40%—personal, or the individual
20%—direction or desire

Does the average engineering school give development through its curriculum, extra-curriculum, and vocational guidance in a similar proportion?

I have had occasion since being asked to cover this subject to speak to several industrial men in the engineering field about this problem. They seem to pretty much agree. One plant superintendent, who was a graduate Chemical Engineer, told me if he had the opportunity to go back to school today, he would most certainly take more courses in the Liberal Arts and Business field, for he said that the majority of his time is spent in dealing with the labor problem. He felt there were certain technics which he could have improved had he had the opportunity to take courses along this line in school.

It is vitally important that the technical man be able to express his technical ideas non-technically. This is true not only in labor but in dealing with the non-technical men within his own organization. Take for example the average labor discussion. On one side of the table are your representatives from the management and on the other are the representatives of Labor. The problem can only be discussed when all the ideas are expressed in the language of the working man.

Could the engineer have been trained in college so that this labor chaos could be avoided? This is not likely, but I do feel it could have been improved. As long as the working, social economic prob-

lems of the two groups differ so decidedly, we can expect some form of misunderstanding to develop between the two groups. If a better understanding of this problem were presented to the young engineer in college, he most certainly would be in a better position to sit down and discuss it with the laboring man.

Do your seniors realize the outlook for the average factory worker? He starts on a job which has a relatively short learning time, and in a short time reaches his peak of earnings and as his home and family responsibilities increase, his earnings in most cases remain the same. Whereas the young engineer starts at about the same rate as the worker in the factory, with the possibility of advancement, and, also, a realization when he has his heaviest responsibilities, he will be at his peak earnings with an increased surety on the job because of his experience and service.

Why are we so concerned with the working man in the factory? In the average industrial concern 75–85 per cent of the personnel are laborers. This means in business and social life most of our contacts are with this group. Does your young engineer realize this, and know how to talk to these men? If not, would it not be well to make a place in your curriculum to explain these problems to him. He will still be living and working with men when his slide rule is forgotten.

TASK OF THE EXECUTIVE IN MODERN INDUSTRY*

By JOHN AIREY

President, King-Seeley Corp., Ann Arbor, Mich.

When I was invited to talk to you on "The Task of the Executive in Modern Industry," I found the subject matter interesting, as I have for twenty years been thinking of this subject in a disjointed way, but I did not like the wording of the title. My first reaction was to suggest a change of title because it put the emphasis on the individual, the *executive*, and emphasis definitely should be placed on the *team*, the organization. On second thought I left well alone, believing that thereby I could establish one of my objectives more effectively. The word "executive" itself merits a passing glance. The American-born child probably first makes its acquaintance at a tender age in connection with early history—Legislative, Judicial and Executive. The Executive is subordinate to, in fact, the servant of the Legislative, and furthermore is exposed continuously to being spanked by the Judicial. The modern authoritarian flare the word has acquired is by no means evident.

It so happens that I clearly remember first hearing the word myself the second or third day after arriving in this country, now thirty years ago. The particular conversation has stuck in my memory because I had to ask what the word meant. It was used by an executive of the Brown and Sharpe Manufacturing Company, in Providence, who was making the statement to me that he was tired of training executives for the automobile industry of the Middle West. He based his refusal of a job for me on the fact that I was foot-loose and would later migrate to Detroit, so advised me to go West right then. I did and am still here. Thirty years later, after receiving Professor Bullinger's invitation, I looked the word up in the dictionary for the first time. It added to my belief in the futility of the dictionary.

Before attempting to discuss the task of the executive, it is fitting to hazard a description, if not a definition, of the type of individual under analysis. I have never been quite sure that the adage about a rose smelling as sweet under another name is wholly true. Some words do psychological tricks. "Executive" is one of these. Its staccato sound suggests an undertow of power, authority and,

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to some, of glitter. Webster does not even hint about authority or the delegation of duties. An executive is one who does, performs, executes. He actually gives the hangsman as an example. What a subject! The modern meaning, in which I suspect no disagreement exists among us here, has injected into educational technique a viewpoint prejudicial to industry's interests. The modern meaning of the term is the exercising of authority, of supervising and of delegating both action and authority. The emphasis is about equally divided between authority, supervision and delegation. The last two are subdivisions of the first. An Irishman might say, "One who works at making others work and so keeps himself busy doing nothing."

Let us examine these qualities of authority, supervision and delegation. They exist in the relation of the housewife to a maid or of a lance corporal to a private, etc., up the line right to the general; in industry, in the relationship of the straw boss to the operator, etc., right up the line to the so-called chief executive. Now if all these people were *wholly* busy exerting authority, supervising or delegating, really, there would be no one actually doing anything except the group of supposedly lowest ability. This hardly makes sense in this reputedly efficient industrial era.

The facts are that everyone above the rank of private, to keep to a military parallel, is occupied with three activities in varying proportions—doing, delegating and supervising. The two latter alone are the executive functions and the proportion that the time spent therein is of total time varies greatly. It is definitely larger in the case of the sergeant than in the case of the general.

Executive action is an attribute of an activity, but it is not an activity in itself. There is no such job as an executive in the sense that there are jobs as an engineer, an accountant, a lawyer, a buyer. Executive action is an appendage to or an attribute of some definite activity and cannot exist apart. An adjective is not very meaningful when standing alone without the support of a noun.

Now I come to the objective of the foregoing dissection. The isolating of attributes, exerting authority and delegating, as if this were an entity and giving this a name, "an executive" is, I submit, an error in thought process which has had undesirable implications. This has resulted in the glamor attached to the term and in attempts to break down into components something that is indivisible—and to the detriment of thought clarity. Literature purporting to facilitate becoming an executive is an intellectual abomination. The so-called executive, like Topsy, "just growed," and direct attempts at forced growth will retard such inherent potential growth as the student may possess. The term "Executive" is

doubtlessly here to stay. Coördinator or Staff Operator is more literally true, and lacks the staccato sound of "Executive."

The Task of an Executive in Modern Industry should read Organization Operation in Modern Industry. Discussion of this centers around the key jobs; *i.e.*, executives of all degrees. A full discussion is a task too big for this address, so I shall limit myself to such factors as are common denominators of all key jobs, meaning thereby jobs in which the occupant, in addition to doing things directly, supervises and teaches others, or, better yet, inspires them to teach themselves, and is responsible for their results. The number of key jobs is great—roughly every fifteenth employee.

An organization is divided broadly into activities—Operating, Sales, Engineering, Accounting, Purchasing and General Staff. Again each of these is split into departments, which are again separated into cells. In spite of idealistic concepts to the contrary, these activities, departments and cells are dynamic—not static. The pulsing of these cells and departments is caused not only by impersonal factors, but much more so by that characteristic we call personality in an individual which governs the effectiveness in that individual of such abilities, training and knowledge as he possesses. The personalities at work in the various cells and departments are continuously causing a change in shape and magnitude of these units. I do not believe that there is any one best way of fitting together cells into departments and departments into activities. The most effective contours will shape up, governed chiefly by the strength and weakness of the appropriate key men, limited only by avoidance of clashing and too much overlapping of responsibilities and authority. Some overlapping is healthy for growth and insurance against slips.

Key men, in addition to the direct activity in which each may be engaged and for which he has had to acquire specific knowledge and understanding, mingle their thoughts and actions with other key men, besides the exercising of authority. Their effectiveness in this new scope has but little relationship to the quality of their specific abilities. In fact, there are incidents when one is inclined to believe it almost has an inverse relationship. Again that characteristic called personality comes in, and the major problem with the key man further up the line is a correct diagnosis of that rather than any attempted training therein. God forbid that educators ever establish a curriculum for the training of personality. Changes occur in that phase in each one of us as years roll on, but that change fundamentally must come by germination from within, caused by the experiences encountered, and any attempt to teach it in the sense that we teach all phases of knowledge and skill is dan-

gerous. It produces a weak, synthetic product. The most one can do in this direction is indirect—by molding environment, furnishing suitable contacts and so subtly encouraging germination from within. This must be done by industry itself as this slow metamorphosis is not a four-year course, but a never-ending process.

Now let us look at the problem of coördination, or tying together of elementary activities, each one of which is comparatively simple. Every manufacturing project involves: Product Design, requiring tracings, blueprints, knowledge of market needs and manufacturing methods; Tool Design, requiring knowledge of machine tools—their scope and limitation, truly a quickly changing subject; Laboratory Facilities, in which all the known sciences are used as exploratory tools; Material Control, involving purchasing, scheduling, follow-up and inspection; Shipping, requiring boxing, routing and tracing; Accounting has cash movements, receivables, payables, pay roll and expense accounts; Office Routine calls for typing, multigraphing, mailing and filing; Sales covers contact work, good will development and market studies; Service gives rise to field activities, education, selection of service stations, complaint analysis and policy shifts as circumstances change; Personnel Department handles selection of employees, vacation policy, welfare, Social Security, and is a clearing house regarding discipline; General Staff, or management, requires continuous study of major key men, liquidity, loans, dividends, new products and plant expansion.

All this is a seething mass which with suitable coördination becomes a more or less smoothly functioning whole, resulting in absorbing a continuous stream of raw material, services and money, and delivering a continuous stream of finished product and money, anticipating that the outward stream is slightly greater than the inward stream of values—the objective of the whole operation.

The problem of coördination is not a mere matter of geometry, of a diagram showing the relationship between activities. True, such a diagram exists in some minds, if not actually on paper, as an organization diagram. This diagram is in a gradual state of flux, with periodically someone straightening out some obvious kinks that have crept into the lines. If all key men were perfect for the respective niches, then the pattern would gradually shift and change to the maximum efficiency of the organization as a whole, and there would be exactly as many points of shift initiation as there are key men. Coördination can never be perfect because it must service conditions which are not static, and a time lag is unavoidable.

To ascertain the degree of knowledge or skill any one person has in a specific subject is not difficult, and the ability to do that we shall take for granted. This then concentrates our attention on the less tangible characteristic which I have called personality for want

of a better designation. This is not trainable in the usual sense, and so the chief good that analysis can accomplish is one of diagnosis, thereby minimizing misplacement of human material and so avoiding the consequent lost effectiveness. This analysis will help toward modification of environment to such extent as may be possible, and thus aid germination from within. I shall attempt to separate out as components such qualities in us which contribute to results in supervision and delegation. It is not easy. Two individuals could have exactly the same knowledge, skill and almost the same judgment in a given activity and yet vary widely in energy, integrity, courage, latent sympathy, clarity of expression, sense of finality, loyalty, cheerfulness, disciplinary attitude, sadistic tendencies, envy, avarice, sense of fair play, et cetera.

Coördination will solve itself if the key men, even though by no means the best picked from the standpoint of subject matter, knowledge and skill, possess a satisfactory composite index of the previously named characteristics.

I believe that every executive, probably more unconsciously than otherwise, pays more attention to these aspects of man than to anything else. The higher in the scale the executive may be, then the more is this true, and the less important is his command of actual subject matter. In fact, as his scope increases, it is increasingly difficult, and finally impossible, to keep intact such thoroughness of knowledge or skill that he may have once possessed, and more and more will his success depend on his correct appreciation of the intangible qualities and so result in more effective placement and growth of key men. Because of the added complexity in modern industry, it is impossible for one brain to keep in focus all activities as may have been more nearly possible formerly, and so it is more necessary that he understand intangibles in human beings, as opposed to former emphasis on subject matter and skill. This minimizes errors in supervision and delegation.

There is, in executive qualities, a great variation, but it is one of degree only. At one extreme we have the executive of fiction, with indefatigable energy, who issues instructions in a staccato manner, suggestive of a machine gun, who knows every detail of every thing under his jurisdiction. He is a brittle pillar of the organization and may snap. At the other extreme we have the type who never issues a single order, but by mingling his thoughts with others causes substantially the same orders to be issued or policies inaugurated in X different places. They are probably better and more timely than those he would have formulated because of the added local coloring and knowledge in the X different places. The truth in practice lies between these two extremes. The nearer one can get to the latter, the better will coördination be. Instead of being

brittle, the latter type is a flexible pillar, and even if he break or disappear, it will not be a calamity.

I don't propose to discuss patterns of coördination in regard to subject matters. Each situation will call for its own prescription, and the topic is relatively unimportant.

It is an elusive job to analyze and weigh the components making up the whole of the intangible characteristics to which I have previously referred. The following comments may help, but remember they are generalizations and there are exceptions to every generalization.

We are concerning ourselves with relationships now, independent of abstract subject matter, relationships between individuals, and I think everyone recognizes what a mysteriously subtle topic this is. Personal pride, likes, dislikes, prejudices exclude the usual scientific attitude.

Energy is an absolute requisite. A man without it cannot lead. It is energy more than brains that makes time schedules—the essence of coördination. It is indefatigable attack, the never let-up attitude, that frequently does the impossible in which better brains have failed.

Without integrity an executive will have but slender bonds between himself, associates and subordinates, and the human machine will fail him when most needed.

Courage is always needed in carrying responsibility, executive or individual. Without it a retreat will be made when success is within reach, and courage, or lack of it, unlike other characteristics, is infectious in group action—infectious as measles.

Latent sympathy or sympathy felt rather than slobbered is a great bond. Many nationally known executives are reputedly tough and hard boiled. It is a veneer. They are sympathetic at heart; otherwise they would not have had the following that helped make them what they are.

Loyalty is an attribute essential in any group activity. Loyalty can be purely toward an individual or it can be institutional. It is always more or less of a mixture. Emphasis on the latter should be encouraged. It is more stable and effective—avoids cliques. What is best *for the company* should always be the criterion.

An optimistic outlook is desirable. Lack of it is usually paid for in ways far from visible. Energy is dissipated in crossing too many imaginary bridges. However, just one member of a board of directors of a sour complex, though otherwise well informed and intelligent, is an asset to be appreciated. Sadism has most definitely no place in an executive's makeup. To get satisfaction in penalizing others is a veritable cancer to healthy discipline. Some castigation is unavoidable in any group effort, but it must be done im-

personally and regretfully. I recall a member of the U. of M. Engineering Faculty, more than twenty-five years ago, saying to me, "I have just had an interesting two-hour talk with Dean Cooley. You know, I had got out of his office before I woke up to the fact that he had fired me—he is a great old boy." I noticed that that same member "resigned" at the end of the year.

Envy must be negligibly present. It is to an organization what sand is in the bearings of a machine tool.

Clarity of thought and expression is greatly to be desired, and formal education can contribute much throughout *all* courses toward this end. Lack of clarity in an executive exacts a toll in lost motion, repetition and errors. I am not thinking of elocution. The orator is good for whipping up a revival meeting to concert pitch, but not for organizing. Good organizers are never good speech makers.

Avarice is a vice. Healthy, sportsmanlike acquisitiveness is an asset. When this becomes so strong that fair, and preferably generous, dealing disappears, it is a cancer in an executive, either stopping or distorting growth.

Self-criticism without any inferiority complex is important. Individual growth is based more on errors committed, but intelligently recognized, than on any other single factor. There are few things so detrimental to organization health as to have a fear complex in the atmosphere—an expectation of having to be error-free. However, I might add that one should be discouraged from making the same mistake twice.

Follow-up and finality are important characteristics and often possessed in high degree by less than average mentalities. This is more of an instinct than are most attributes. It is an involuntary consciousness of an unfinished chore and a resulting continuous pressure, then a very conscious check-off when finished. Many people don't quite finish a job.

Social characteristics in key men are an important zone for observation. Corporate authority has no rights over private lives, but that is no reason for shutting one's eyes to probable sequels to visible tendencies which are likely to react organizationwise. Thrift is the art of consuming less than one produces. Industry, if successful, results in accretion to capital. The correlation factor between individual economic soundness and industrial growth in key men is quite high.

The urge to be socially prominent is a deterrent to the growth of one's industrial value. It takes too much energy—the supply of which is finite. Social contacts among people of the same organization are best for organization good when minimized for the two reasons that confusion of personal prejudices is correspondingly

reduced and it is better for individual development to be exposed to contacts other than those already made in daily routine. In addition, organization changes inevitable with time are usually made with fewer inhibitions if bonds outside of the company are weak—to the good of the organization as a whole and to all the key men individually.

Last, but most important of all, is a combination of energy and enthusiasm—that intuitiveness to work, not a six, eight, or even ten-hour day, but psychologically a twenty-four hour day, when certain situations develop—an automatic subordination of all other aspects of life for short periods. There are industrial hurdles which a twenty-four hour day for a few weeks or months will successfully take, but which a fixed working day would *never* take. It is the intensity of continuity that registers rather than the time integral of effort applied. Those incapable of such application never recognize the challenge of such hurdles—they are invisible. Every being who has ever done creative work is aware of such type of application. The creative work of the artist stands with its own individuality permanently. The creative work of executives spreads, diffuses and finally sublimates into the cement which holds together as effective producing machines our industrial organizations.

These are characteristics inherent, in varying degrees, in each one of us. They change slowly through the years, influenced by environment. The tasks of any executive in modern industry are (1) to see that the key men under his jurisdiction are the best available material and to continuously help develop their strong points and minimize their weak points, (2) to mingle his thoughts and actions with other key men associated with him for the greatest good of the joint activities or of the organization as a whole, (3) to state his own conviction without reservation to his superior executive, but to carry out the required policy just as whole-heartedly whether in agreement or not, (4) to act naturally—just be himself—without fear or favor.

Panaceas such as an idealistic line diagram accomplish very little. If there is one place where a robot should not be found, it is in a key position.

I regret that such thoughts as I have been able to contribute could not have been more lucid. In conclusion, let me say that I have long considered it has been a psychological deterrent to balanced judgment that more or less of a halo has developed around the executive, giving substance to the concept that authority alone can constitute a job instead of it being merely an attribute to the performing of specific duties.

NECROLOGY

Walter H. Dunagan, Associate Professor of Theoretical and Applied Mechanics at Iowa State College, died Monday, November 24th as a result of an emergency operation for a stomach ailment.

Professor Dunagan was born in Des Moines 47 years ago, was a graduate of East Des Moines High School, had an A.B. degree from Simpson College 1919, a B.S. in Civil Engineering from Iowa State College 1923, followed by degrees of Civil Engineer 1928 and Master of Science 1930. His freshman year was spent at Grinnell College.

After preliminary field experience with the South Dakota and Iowa State Highway Departments, Mr. Dunagan joined the Civil Engineering Staff of Iowa State College in 1924 and in 1933 became associate professor of Theoretical and Applied Mechanics. He had long been interested in construction and engineering materials, his best known technical contributions being the result of his researches and writings in the field of concrete. In this field his name was internationally known and he was drawn in as a consultant on a great variety of concrete problems many of which were in connection with novel or large construction.

Professor Dunagan was the inventor of equipment widely used in the analysis of fresh concrete; the author of two important bulletins of the Iowa Engineering Experiment Station, one on the Field Control of Concrete and the other on the Use of Color in Concrete; of a manual for use in the teaching of courses in plain concrete and of several technical papers and discussions published in the proceedings of the American Concrete Institute and the American Society for Testing Materials. About five years ago he developed a type of reinforced tile floor construction which already has gained wide acceptance and use. One of his most interesting and successful researches was his own residence of monolithic concrete, completed only a year ago in which he embodied many unique features of both a utilitarian and artistic nature.

His membership in professional and technical organizations included: The American Society for Testing Materials in which he had long been active, being chairman of Subcommittee VIII of 69, on Permeability Tests of Concrete; American Concrete Institute, some of his most recent labors having been in connection with the work of Committee 613, on the Design of Concrete Mixtures, besides being chairman of Committee 408 on Color in Concrete; and

the Iowa Engineering Society of which he was for a number of years chairman of the Committee on State Building Code. He was also a member of the Society for the Promotion of Engineering Education and was a registered engineer in the state of Iowa.

Manford W. Furr, born at Veedersburg, Ind., August 24, 1888, died November 16, 1941.

Professor Furr received the degree of B.S. in C.E., in 1913, and the C.E. in 1925 at Purdue University. He received the master of science degree in civil engineering at Kansas State College in 1926.

He came to Kansas State College as an instructor in civil engineering in 1917, and was advanced to the rank of full professor in 1927. He was a specialist in highway engineering in which he did special research work and had had experience in this field with the highway commissions of South Dakota and Kansas. Professor Furr wrote numerous pamphlets and bulletins on civil engineering.

Professor Furr was an active member of this Society especially in the work of the Civil Engineering Division. He had been a member of the Society since 1917.

RECENT DEATHS

Alford, L. P., New York University
Carpenter, H. V., Washington State College
Cary, E. R., Rensselaer Polytechnic Institute
Drake, E. B., Wayne University
Higbie, R. W., University of Louisville
Kidd, J. W., Texas College of Mines and Metallurgy

SECTIONS AND BRANCHES

The Fall Meeting of the **Middle Atlantic Section** of the S. P. E. E. was held at the School of Technology of the College of the City of New York on Saturday, December 6, 1941. The meeting was attended by 231 men and 23 women. The morning program, which started at 11 A.M., consisted of six divisional seminars. These seminars covered a civil engineering forum, a discussion of defense training in chemical engineering, a paper on ultra high frequency techniques by the Electrical Engineering Department, a paper on production processes by the Mechanical Engineering Group, a drafting seminar and the general meeting on defense training courses. In addition to these technical meetings, the librarians of the various technical colleges in the Section met to form a librarians' organization. These technical meetings were all held in the Engineering Building of the City College. Luncheon was served at 12:30 and was followed by a General Session at 2 P.M.

At the General Session Harry N. Wright, President of the City College of New York, extended greetings to the Society. He then introduced Alfred H. White, President of the Society for the Promotion of Engineering Education, who addressed the group on the general subject of "The Present Job of the S. P. E. E."

President White indicated that the coming National Meeting of the Society would not be concerned so much with national defense courses as it would with the general topic of progressive education. He intimated that the engineer must assume more and more responsibilities in present-day society and definitely must prepare himself for these responsibilities. Whether or not the ideas of the progressive educational group met these requirements is a subject for discussion. He intimated that we can expect quite a few changes during this war period in the present setup of engineering colleges. He also indicated that the general subject of human relation education in engineering was a very large subject at the present time.

At the conclusion of this address President Harvey Davis of Stevens Institute of Technology spoke briefly on the monies to be appropriated during the coming year for national defense training. He intimated that some thirty-five million dollars may be appropriated to be spent on defense training courses of the college level. This sum exceeds the combined budgets of most of the engineering colleges in the country.

In view of the possible decrease of college finances due to high taxation and the drafting of students and through other causes, he suggested that some of this money could well be used to help finance the regular college budgets and to promote research in engineering. He suggested definitely that approximately ten per cent of this sum should be allotted to the colleges in the way of student aid and scholarship and an additional three per cent to promote postgraduate student scholarship.

At the conclusion of his remarks a resolution was passed in which the Middle Atlantic Section went on record as approving the general ideas as expressed by President Davis. A resolution to that effect will be prepared and sent to the Department of Education in Washington.

At the conclusion of the papers presented at the General Session a Business Session of the Section was called to order by Charles G. Thatcher of Swarthmore College, chairman of the Middle Atlantic Section. The minutes of the Villanova meeting were approved and the Treasurer announced a balance on hand of $130.00. The next meeting of the Section was set for Saturday, May 9, 1942, at Princeton.

As indicated in the morning session, the librarians associated with the engineering colleges of the Middle Atlantic Section met to discuss the organization of a separate division under the S. P. E. E. At the business meeting of the Section the librarians, through their chairman, J. B. O'Farrell, presented a petition signed by fourteen members asking that the Middle Atlantic Section recognize the librarians' group as a division of that Section. Their petition was approved by the membership. The next order of business was the election of officers for the coming year. The Nominating Committee under the chairmanship of Dean E. J. Streubel of the Brooklyn Polytechnic Institute placed in nomination of the following slate: For Chairman, Professor J. S. Morehouse of Villanova; for Vice-Chairman, Mr. D. F. Lane, Superintendent of Apprentice, Bethlehem Steel Corporation, Sparrows Point, Maryland; for Secretary-Treasurer, Frank D. Carvin of the Newark College of Engineering.

There being no further nominations, the above slate was elected to office.

Following the business meeting, the entire assembly convened at a tea and reception offered by the President of the City College of New York. Following this, the meeting adjourned at 6 P.M.

The Section wishes to thank very much the Faculty of the City College of New York for their kind hospitality and particularly Professor S. J. Tracy, General Chairman for the City College.

FRANK D. CARVIN, *Secretary.*

North Carolina State College.—The officers of the local branch of S. P. E. E. for the present year are H. B. Briggs, Chairman; C. R. Bramer, Vice-Chairman and Chairman of Program Committee; A. M. Fountain, Secretary-Treasurer; and J. W. Cell, Corresponding Secretary.

The Membership Committee is hard at work with the aim of making the membership in S. P. E. E. at this college 100 or more, and they have nearly reached that goal. The programs this year are to be upon such topics as "The Counciling System," "Vocational Education as Applied to this Section of the U. S.," "Modern Methods of Teaching Descriptive Geometry," "Scheduling and Registration Problems," etc.

Beginning with the present freshman class, all students will be required prior to the end of their sophomore year to take a citizenship test and, in the event of their failure to pass this examination, will be required to take a course in American Government as a part of their college curricula. It is hoped that the students will thus be encouraged to read current magazines and to keep abreast of both national and international events.

The enrollment this fall is 1,344, a gain of 1.5 per cent over that of the fall term a year ago. The Aeronautical Engineering Department was established last year as a separate department, and this year is housed in a new brick and steel single story building. Professor L. R. Parkinson is Acting Head of that department.

Professor Harry Tucker has been made a member of the N. C. Utility Commission. Professor T. S. Johnson has been appointed State Director of Civilian Defense. Professor J. L. Stuckey has been made State Geologist. Professors F. F. Groseclose, Carter Williams, G. G. Fornes, P. E. Moose, and J. T. Massey have been called to active duty with the army.

The following additions to the faculty have been made this fall: Instructor J. N. Smith, Jr. in Ceramic Eng.; Associate Professor F. W. Pearce in Civil Eng.; Assistant Professor R. F. Rautenstrauch in Aeronautical Eng.; in Mechanical Engineering as instructors: J. C. Cheatham, T. E. Hyde, R. E. Lake (transferred from Math. Dept.), P. B. Leonard, W. Mc Neale, E. H. Stinson, and E. L. Perry; in Mathematics as instructors: Robert Hooke, C. W. Seekins, C. F. Strobel, and R. L. Anderson; Instructor Frank Seely in Chem. Eng.; Instructor W. L. Parker in Physics; Assistant Professor J. H. Grady in Arch.; Instructor J. M. Page in Arch. Eng.; Instructor C. N. Gaylord in Eng. Mech.; Professor L. D. Huff is an exchange professor in Physics from Clemson for Professor J. S. Meares who is teaching at Clemson and working on a research project. W. G. Van Note has returned after a leave of absence to get his Ph.D. degree at Penn. State and is now As-

sociate Professor in Chemical Engineering. W. G. Friedrich, distinguished engineer and economist of Czecho-Slovakia, joined the Aeronautical Engineering faculty in the middle of last year.

North Carolina State College and Duke University are to be joint hosts to the Southeastern Section of S. P. E. E. next spring, and plans are already under way to make this meeting a real success.

38 preëmployment courses have been given under the auspices of the E. D. T. and the E. S. M. D. T. and 746 men have been trained for their first engineering jobs. The number of students who have completed the primary course in the C. P. T is 230 and 69 have completed the secondary course.

COLLEGE NOTES

University of Detroit.—The enrollment in the Engineering College has increased 4.2 per cent over the enrollment of last year, 892 students having registered against 857 in the fall of 1940.

In addition to the enrollment for regular engineering courses, 548 students have enrolled for eighteen defense courses being offered in the evening.

The College of Engineering is offering two separate preparatory courses for entrance into the Army Air Corps.

One of the courses known as the Air Corps Preparatory Course requires regular college entrance credits and consists of fifteen semester credit hours of work in English, history, mathematics and chemistry for two semesters. Upon satisfactory completion of this work the student is admitted into the Army Air Corps without further academic examination.

The second course is known as the Aviation Cadet Institute Course, which has no pre-requisites and is non-credit in character. The purpose of this course is to prepare men for the written entrance examinations required by the Army Air Corps. This course covers subjects on U. S. History, world history, arithmetic, algebra, plane geometry, trigonometry, English, grammar and composition for six hours per week during a period of twelve weeks.

Through the efforts of Leon S. Johnston, Professor of Mathematics, The University of Deroit Pioneered the Introduction of the Air Corps Preparatory Course. Eleven other colleges are now offering a similar course.

The 1941 Charles T. Main Award of the American Society of Mechanical Engineers was awarded to John J. Balun, a mechanical engineering graduate in June of this year.

The Charles Main Award is the principal undergraduate award in mechanical engineering in the United States and Canada. The award is made to the student writing the best essay on a subject selected by the Board of Honors and Awards of the American Society of Mechanical Engineers.

Balun is employed by the General Electric Company at Schenectady, New York.

Jasper Geradi, director of engineering drawing has been appointed chairman of the Society of the Promotion of Engineering Education's Committee on Defense Training Courses in Drawing.

The Committee will investigate the progress being made on defense courses in engineering colleges throughout the country.

Faculty changes and promotions in the Engineering College include the following:

Mr. Julius T. Banchero, instructor in chemical engineering, has resigned to continue his studies for the Doctor's degree at the University of Michigan.

Mr. Henry P. George, instructor in metallurgy, has resigned to do industrial work in the State of Pennsylvania.

Mr. Columbus Floyd, a former instructor in the metallurgical and Mechanical Engineering at Tulane University, has been appointed instructor in metallurgy.

Mr. E. Clarence Oden, formerly a teaching fellow at the University of Michigan, has been appointed instructor in chemical engineering.

Professor George J. Higgins, acting Director for the past year of the Department of Aeronautical Engineering, has been appointed Department Head.

The Department of Engineering Mechanics has completed the installation of a new 200,000 lb. Olsen testing machine in the engineering laboratory. This machine will accommodate column specimens 12 feet in length and beams with spans of 20 feet.

CLAIR C. JOHNSTON, *Chairman,*
Publicity Committee,
Engineering College.

Purdue University.—The $270,000 Duncan High Voltage Laboratory and South Wing addition to the Electrical Engineering Building was completed and occupied during November. A feature of the Duncan Laboratory is the large free space—60′ by 120′ with a height of 60′, that will house a three-million-volt Marx Surge Generator as well as high potential, 60 cycle and radio interference testing equipment.

The south wing addition has doubled the facilities available for instruction and research in Electronics. A large area has been allotted for use as a departmental library.

A joint meeting of the staffs of the Schools of Engineering and the Department of Physics was held on November 13 in the new Chemical Engineering Building. There was presentation and discussion of a committee report on "Humanistic-Social Studies in the Optional Five Year Curriculum." A feature of this curriculum is the availability of time for numerous elective courses which results in considerable flexibility for student programs. A pro-

posal was made for instruction of a historical survey course stressing the progress of mankind in his attempts to correlate social, political, economic, and scientific developments.

"Teaching Methods in Basic Physics Courses" was the topic of a committee report and of the subsequent discussion. The use of lecture demonstration techniques that emphasized the law of variation between physical quantities was described. There was an evaluation of the success of the use of a short, written recitation at the beginning of each regular recitation period.

OUR ANNUAL MEETING

By ALFRED H. WHITE, President

Some of the members of our Society have queried whether we should not cancel the Annual Meeting scheduled for New York City June 29 to July 2. They have feared that so many of our members would be teaching in the long summer term and perhaps carrying additional burdens of war work that they could not spare the time to attend the meetings. The restrictions on tires and the increased railroad rates would also decrease attendance.

The attitude of another group of members has been that now, when the engineering colleges are assuming an unusual load and are faced with many new problems, there is an unusually urgent need for conferences, and for reports from those who are in close touch with the changing national situation.

Inquiry among the other national engineering societies has shown that they plan to hold their regular meetings this summer, and believe that the programs will be more important than usual. The Engineering Institute of Canada held its annual meeting in February with the largest attendance in its history.

The New York Committees preparing for our Annual Meeting report that their plans are progressing smoothly and that, from their view point, there are no obstacles to successful meetings. Chairmen of Divisions and Committees are planning special consideration of war problems at their conferences. The general sessions of the convention will also be devoted to our part in the war effort. The latest developments in Washington will be reported by speakers with first-hand information. An attempt will be made to forecast the immediate future demands for engineers by industry and the armed forces. There will be reports on the status of the accelerated programs in our colleges.

The Annual Meeting will be held unless a preliminary canvass indicates a poor attendance. A questionnaire went to the deans of our engineering schools early in March. Unless their reports are discouraging, our Society will hold its Annual Meeting in New York as planned.

NEW YORK INVITES YOU

Host City for 1942 Annual Meeting *

By HAROLD E. WALTER †

This city, which will provide the setting for the Annual S. P. E. E. Meeting this summer, offers opportunities in sight-seeing and inspection which will satisfy even the most discriminating. The city proper is composed of five boroughs—Manhattan, Brooklyn, Bronx, Queens and Richmond. Over thirteen million people, of whom nearly eight million live in New York City, reside within the Metropolitan area, which may be represented as a circle of forty-mile radius.

The visitor approaching this city views a maze of man-made structures, the number and immensity of which are unequalled anywhere. Something slightly more than three centuries has sufficed for the building of this city. This short construction period is in itself evidence of the dynamic nature of our American civilization —in fact, to the born and bred New Yorker it is our civilization. But whether this be true or not, no one can deny that it is at least an expression of some phases of it.

Manhattan Island was discovered by Henry Hudson on September 11, 1609. In 1613 the first habitation for white men was built by Adrian Block at the site now located at 41 Broadway. In 1626 Peter Minuit, who was then governor of the settlement, purchased Manhattan Island from the Indians for a few trinkets valued at about twenty-four dollars. When one considers the fabulous value of the real estate on this island today, it seems that old Minuit was, in addition to being a good governor, a bit of a trader in his own right. Thus the history of New York really starts with the year 1626, although it was not incorporated as a city until 1653.

Naturally the tremendous resources available to the visitor to New York and its surrounding area cannot be listed in the space of an article. The Local Committee in Charge of Arrangements

* The reader is referred to the Federal Writers Project guidebooks of *New York* (Oxford University Press, 1940), *The City of New York* (Random House, 1939), and *New Jersey* (Viking Press, 1939) from which some of the material of this article was taken. In these books one will find complete and detailed description of all the attractions of the New York area.

† Professor Walter, of Newark College of Engineering, is Chairman of the Publicity Committee, S. P. E. E. Annual Meeting, 1942.

for the S. P. E. E. Annual Meeting in June is glad to announce, however, that its Information Committee will make every effort to have guide books and maps available here when you arrive in New York, so that you may learn about and find easily the places of the most interest to you. In addition to this, the Committee on Inspection Trips and Excursions is already holding sessions to discuss arrangements for as many interesting tours as can possibly be crowded into the short time you will be in New York. This Committee is planning not only trips to all the host institutions and to noted projects and plants of outstanding engineering interest, but, together with the Committee on the Women's Program, is arranging trips for the less serious purpose of mere entertainment.

We do want, however, to mention a few types of things you will want to see, and a few examples of these types. The list cannot begin to comprise all the local attractions; but with the twelve host institutions representing not only all of New York City but also large sections of some of the most interesting territory in New Jersey, a wealth of opportunities will greet you here.

In and around the harbors and rivers of Greater New York the islands, bridges and tunnels are the outstanding attractions, particularly to the engineering visitor. The Port of New York, served by more than three hundred motor truck lines and ten trunkline railroads, embraces an area having a population of twelve million. In this region about 40,000 industrial establishments annually produce goods valued at eight billion dollars. Within the City limits five hundred and eighty miles of shore line are dotted with eighteen hundred piers, wharves and bulkheads. The Hudson River waterfront of Manhattan is bordered with the piers of the great trans-Atlantic and South American shipping companies. Normally about two hundred vessels enter the harbor every day, and some eighty thousand men are constantly employed in handling cargoes, tugs, barges, scows and lighters at the port. Most interesting of the islands in the harbor is Bedloe's Island, holding the now famous Statue of Liberty enlightening the world (boat trip and admission are fifty cents).

The Metropolitan district has demanded outstanding engineering feats in order to effect transportation and traffic facilities in so densely populated an area. The Brooklyn, Triborough and George Washington bridges are all famous examples of their types of construction, while the Holland and Lincoln Tunnels under the Hudson River and the Queens Midtown Tunnel under the East River demonstrate what splendid engineering feats the necessity for transportation has caused to be accomplished in the city. The Holland Tunnel alone is used by twelve and a half million cars annually.

Manhattan can possibly be best described by considering the wanderings of its most famous street, Broadway. This thoroughfare, the longest and most fantastic street in the world, starts its sixteen-mile journey from the Battery on the lower tip of Manhattan. It then moves through the Wall Street financial district, passes the civic buildings of the city, by Union Square and through the needle-trades area between 34th and 39th Streets. Between 42nd and 53rd Streets Broadway is the Great White Way, rennowned as an amusement and theatrical center. From 53rd Street to Columbus Circle it cuts through Automobile Row, center of the auto retail trade. At 79th Street it parallels the Hudson River, and here it is lined with hotels, apartment houses, beauty salons, movie houses and churches. At 114th Street, Broadway is bordered by Columbia University, and at 155th Street by a group of museums. From here on it is merely another street, ending in a suburban road as it approaches the city limits.

Some of the greatest churches in the country lie in the New York area—St. Patrick's Cathedral, whose beautiful Gothic portals are reflected in the great windows of Rockefeller Center across Fifth Avenue; the Cathedral of St. John the Divine (so near Columbia University that it can be visited easily from the Annual Meeting Headquarters), which will be when complete the largest Gothic cathedral in the world; the beautiful Romanesque structure of Temple Emanuel on Fifth Avenue; historic old Trinity in the Wall Street district; and the Riverside Church (also very near to Columbia) which is famous for its carillon of seventy-two bells. The observation tower of Riverside Church affords the visitor an excellent view of the surrounding area (admission 25c).

Museums in New York cover every field of human interest, while the libraries in the City—dozens of libraries in special fields, besides the great Public Library—are a never-failing mine of information. At the Museum of Science and Industry in Rockefeller Center, for instance, you can see for twenty-five cents admission fee a complete behind-the-scenes view of the industrial age we live in. There are special geographical, historical, scientific, numismatic and many other types of museums well worth visiting, while the art museums of New York are famous the world over. Many formerly private collections are now open to the public, such as the Frick Collection; the Metropolitan Museum needs no introduction to anyone; and the Museum of Modern Art is the finest museum of its kind anywhere. One of its most interesting features is the daily moving picture at four o'clock included in the twenty-five cent admission price. The pictures are run in cycles showing the history of the film, and many an old favorite appears on their programs.

There is much interest to be found, too, in many of the civic buildings of New York. The old City Hall is reminescent of a Louis XVI palace; Grant's Tomb, within easy walking distance from the Columbia campus, is a shrine which has been visited by more than fourteen million people. One of the most beautiful new City buildings is the new Tombs prison, which forms a very striking contrast to the grim, fortress-like old Tombs across the street from it.

Of course the most completely characteristic feature of the New York scene is the skyscraper; the terrific scramble for space in the city has resulted in some architectural feats of breath-taking size and beauty. All the great towers are open to the public(for a fee ranging from fifty-five cents in the Woolworth and Chrysler Buildings to a dollar and ten cents in the Empire State) and the panorama laid out before the eyes of a visitor to one of these heights is of course indescribable, and well forth seeing.

Although the above points of interest are chiefly in Manhattan, the visitor to New York will also find many places of attraction in the other sections of Greater New York. In Brooklyn is to be found the historic Church of the Pilgrims, which dates back to the pre-Civil War period and was the scene of many fiery blows struck for social reform in that day by Dr. Henry Ward Beecher. One of the first and largest of the Federal Housing Projects is found in North Brooklyn in the Williamsburg Houses, a very successful and beautiful example of such buildings. The Brooklyn Museum is considered exceptional as an unit of the educational system of Brooklyn as well as for its beautiful collections.

Flushing Meadow Park in Queens, the former site of the New York World's Fair of 1939–40, is fast nearing completion, and the visitor of two years ago will be delighted to note the transformations which have occurred to make this one of the city's most attractive parks. LaGuardia Airport, also in Queens, regarded as the world's leading airport, is of modern design and construction. Over two hundred planes a day arrive here from all parts of the United States, in addition to the many trans-Atlantic and Pan-American clippers from the other parts of the world.

In the Bronx one of the outstanding attractions famous throughout the world is the Bronx Zoo and Botanical Gardens. The cottage of Edgar Allan Poe, where he lived for three years and wrote some of his more famous poems, is also here. St. Paul's Episcopal Church, which was built in 1765 and included among its early members such historic New York families as the Roosevelts, Pells, Van Cortlandts, etc., is a beautiful example of the architecture of this period.

On the New Jersey side of the Greater New York area, one will find in Hoboken one of the most picturesque and cosmopolitan streets of the New York harbor area—River Street adjoining the Hudson River. Newark is one of the largest of our industrial centers, housing nearly every conceivable type of manufacturing establishment. It is hoped that some of the factory inspection trips will be planned for this area. The Newark Airport, originally the airport for New York City, has become in recent months one of the largest of the country's aeronautical manufacturing centers. The Port of Newark, transformed not long ago from a salt marsh to a $90,000,000 seaport terminal, is the scene of tremendous activity these days in the transportation of war products.

But the really desirable opportunity for educators planning to attend the S. P. E. E. Annual Meeting is the chance of becoming acquainted with the twelve host institutions—all located in Greater New York and all engineering schools of distinction. In this and subsequent articles, therefore, we are planning to give you thumbnail sketches of each school, so that you may even now begin familiarizing yourself with some of their features of interest. The first of these sketches are presented below.

All in all, this area provides opportunities for recreation, education and pleasure which are today without equal. In a normal year visitors numbering in the hundreds of thousands enter this city just to see, absorb and remember the panorama which everywhere encompasses one. To the uninitiated, it is an unbelievable experience; to the initiated it is a never-ending source of wonder and satisfaction. Combine the opportunities which this city offers to the visitor with the reasons for attending the Annual Meeting of the S. P. E. E., and you have an overpowering argument which should compel you to visit with us this summer.

THE CITY COLLEGE OF THE COLLEGE OF THE CITY OF NEW YORK

The City College, the largest municipal institution of higher learning in the world, is this year celebrating the ninety-fifth anniversary of its founding.

To its many thousands of students and alumni, the College stands as a meaningful symbol of democracy, for to its halls come young men and women from all economic levels and national backgrounds, selected on the basis of intellectual superiority and afforded the opportunity of a free higher education that might have been denied them if it had not been so wisely provided by the people of the city. Many of its graduates have attained positions of distinction in all walks of life. They include such men as Supreme Court Justice

Felix Frankfurter '02; Senator Robert F. Wagner '98; former Ambassador Henry Morganthau '75; General George Washington Goethals '77; Cleveland Abbe '57, founder of the United States Weather Bureau; Bernard M. Baruch '89; Ira Remsen '65, former President of Johns Hopkins University; Gano Dunn '89, President of Cooper Union; John Russell Pope '93, the eminent architect; David B. Steinman '06, who has designed some of the world's leading bridges; William H. Park '83, discoverer of the cure for diphtheria, and a large host of others whose citations can be found in Who's Who, Men of Science, the Dictionary of American Biography, and other leading reference works.

The main building of the College stand on St. Nicholas Terrace near 139th Street, one of the highest points in the city. They were constructed in 1907 and today accommodate some of the largest units of their kind. The Summer Session, now celebrating its twenty-fifth anniversary, is the largest public Summer Session in the world. The School of Technology, with an enrollment of 3,778 students, is the second largest engineering school in the country. The Evening Session, with more than 13,000 students, has the largest night unit, and the School of Business and Civic Administration, occupying its own 16 story building in midtown Manhattan at 23rd Street and Lexington Avenue, is the largest School of Business in the world. However, the College is proud not so much of its magnitude as of the quality of the work it is performing.

City College has long been famous for the high level of its intellectual atmosphere. The regular entrance average for boys is 84 per cent for the entire four year high school course, and for girls it ranges up to 89 per cent. Last year, on the intelligence test given by the American Council on Education to freshmen of some 300 leading universities and colleges in the United States, the City College entering class ranked fifth. As for the faculty, more than 75 per cent of the full-time staff have doctorates from leading universities, and in spite of the heavy teaching schedule, they conduct a good deal of research. In the last eighteen months they published some 96 books and more than 500 articles in scientific, scholarly, and professional journals.

Although the scholastic program the students follow is in a sense exacting because of the high standard of scholarship in the College, they nevertheless have one of the most extensive extra-curricular programs in the country. More than 6,000 students take part in voluntary intramural athletics, and sixteen varsity teams represent the College in all of the major sports. The chess team last Christmas won the Intercollegiate Tournament, and the basketball team ranked third in the country. The boys also voluntarily elect Military Science, and City College has the largest

voluntary R. O. T. C. unit in the country with more than 2,100 cadets.

The College has geared all its resources behind the nation's war effort. The R. O. T. C. unit has already trained close to 25,000 boys in its basic course, and has prepared some 700 men for commissions in the Army. It is now conducting twenty-one defense training courses under the auspices of the United States Office of Education, and is providing special instruction for pilots in its civil aeronautics course. The Division of Public Service Training offers in-service courses for employees of city departments, and pre-service courses to candidates for the police and fire departments. Our Social Research Laboratory provides counsellors and guidance experts for public and private social agencies, and the Educational Clinic, the first in the country, treats maladjusted children sent to it by the city schools and social agencies. Both the students and faculty have organized comprehensive programs in civilian defense and general aid to the nation in its emergency.

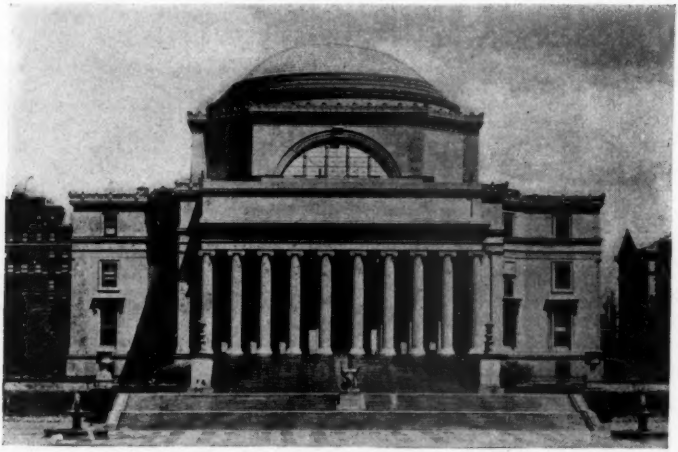
Established in 1847 the College, originally called the Free Academy, is administered as one of the four municipal colleges in the city by a Board of Higher Education appointed by the Mayor. It gives degrees in the Arts, Sciences, Social Sciences, Engineering, Education, and Business. Its Main Center campus has become a mecca to which music lovers from all over the country come to hear the beautiful Stadium concerts presented in the Stadium given to the people of the city by Adolph Lewisohn.

COLUMBIA UNIVERSITY

Columbia University, site of the S. P. E. E. Annual Meeting Headquarters, was founded as King's College in 1754, when instruction in the first class of eight students began under the Rev. Samuel Johnson in the Vestry Room of the schoolhouse of Trinity Church in lower Manhattan. Now in its 188th year, the University comprises twenty-one schools and divisions which annually enroll more than 30,000 students who receive instruction from approximately 3,300 professors, instructors, and lecturers. Its living alumni, residing in virtually every city in the world, total more than 107,000.

Core of the University's domain is the Morningside Heights Campus where the Schools of Engineering, Architecture, Law, Business, Journalism, and Library Service, as well as Columbia, Barnard and Teachers Colleges, are located. Graduate instruction in political science, philosophy, and pure science is also provided here. The University Libraries, containing more than 5,000,000 volumes, regularly display exhibits of current interest.

Headquarters of the S. P. E. E. Annual Meeting next June will be in Low Memorial Library, an eminent example of classical architecture rising majestically in the center of the campus. Recently voted one of the ten most beautiful buildings in America, Low is designed in the form of a Greek cross and is surmounted by the largest dome of solid masonry ever built in America. The President's office and other administrative offices, priceless collections of rare books, and special libraries surround the vast, museum-like rotunda often used for University exhibitions.



LOW MEMORIAL LIBRARY, COLUMBIA UNIVERSITY.

Daily Chapel services, in which a student choir of forty voices participates, are held in conformance with provisions of the founding charter. Almost nightly, outstanding speakers and artists appear at the Institute of Arts and Sciences. CURC, student-built and operated Campus radio station, broadcasts sixteen hours a day from its studio in Hamilton Hall. University organizations which contribute to the cultural and social life at Morningside include the Casa Hispanica, Casa Italiana, Maison Francaise, Deutsches Haus, and the Japanese Cultural Center.

The development of the Columbia School of Engineering began in 1864, when the School of Mines, first of its kind in the United States, was established by the Trustees acting on the proposal of Thomas Egleston. Engineering education has kept pace with the University's expansion until now the School encompasses the departments of mechanical, chemical, civil, electrical, and industrial engineering in addition to the School of Mines.

"Tommy Rocks," as Egleston came to be known, collected the items which formed the nucleus of the Egleston Mineralogical Museum in Schermerhorn Hall. One of the country's largest cyclotrons, a 65-ton atom-smashing mechanism that accelerates positive ions to energies of ten million electron volts, is in the basement of Pupin Laboratories. Atop Pupin, the Rutherford Observatory houses a twin-refractor telescope with 12-inch visual and 13-inch photographic lenses.

In nearby Chandler, a microörganic laboratory contains devices capable of measuring vitamin content and analyzing food samples as small as 2/1000 of a gram. The isotope laboratory, in which Nobel Laureate Harold C. Urey made his discoveries of heavy water, hydrogen, and nitrogen, operates twenty-four hours a day with a six-man crew. Strength of materials testing machines with a capacity up to 600,000 pounds are located in the Engineering Building. In the Mines Building are electric furnaces which generate heat almost beyond the power of man-made instruments to measure.

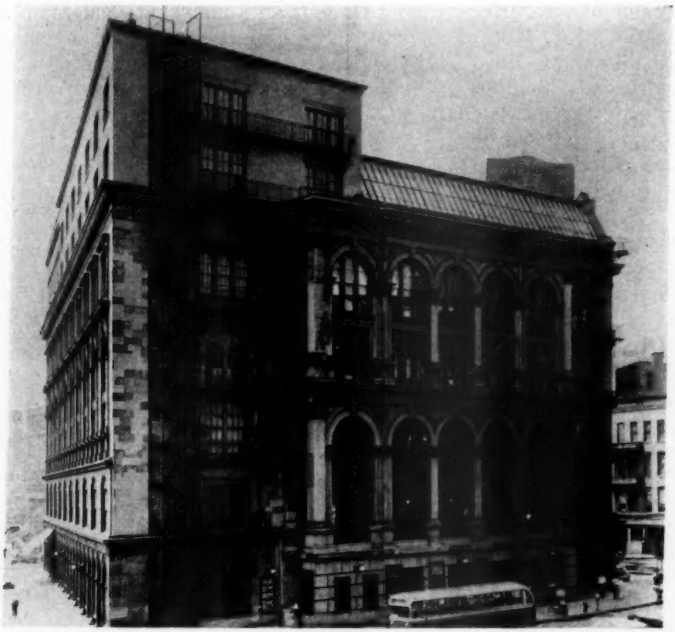
Within these laboratories many outstanding contributions to science and industry were developed. It was here that Irving Langmuir perfected the vacuum tube found in every radio; that Michael I. Pupin derived the method of loading cables that made modern communication possible; that Edwin H. Armstrong invented the static-free frequency modulated radio transmitter; and that the soils which supported the New York World's Fair were tested.

One of the most recent additions to Columbia's engineering facilities is a laboratory devoted to unsteady state heat transfer and utilizing an electrical analogue to investigate temperature changes within a structure in a fraction of the time they normally take to occur. In the chemical engineering laboratories, faculty members and graduate students are now devising processes with the hope of freeing the United States from the threat of shortages in vital defense materials.

COOPER UNION

Located in the heart of downtown New York, The Cooper Union is one of the City's earliest landmarks. Its seven-story Foundation Building, erected in 1859 at Seventh Street and Fourth Avenue, now called Cooper Square, was the first of the modern sky-scrapers. From the platform of its historic Great Hall, Abraham Lincoln, in 1860, delivered "The Cooper Union Address" against slavery which won him the support of the East in his first campaign for the presidency. In addition to the Foundation Building, Cooper Union includes a modern engineering building also located in Cooper

Square. Founded by Peter Cooper, an unschooled New York mechanic who became one of America's greatest inventors and industrialists, the institution for eighty-two years has been carrying out the philanthropist's life-long dream to provide "free courses of instruction in the application of science and art to the practical business of life." Tuition in the day and night art and engineering schools is free to all who meet the entrance requirements irrespective of race, creed, color, or place of residence.



COOPER UNION—NEW YORK'S FIRST SKYSCRAPER

The Night School of Engineering, oldest division of the institution, is a six-year course in Mechanical, Electrical, Civil and Chemical engineering designed to help men already in the industry. It has been in continuous operation longer than any other evening engineering course in the country. No previous formal education is necessary, as long as the candidate for admission can survive the rigid competitive examinations which eliminate six out of every seven applicants. Four-year courses are given in the Institute of Technology, the day school of engineering, and in the Day and

Night Schools of Art. Classrooms, laboratories, and art studios are available for more than 2,000 students a year in the Foundation Building, which also contains reference libraries, reading rooms, and a museum, and in the Hewitt Building, constructed in 1912 as a public memorial to Abram S. Hewitt, former mayor of New York and a son-in-law of Peter Cooper.

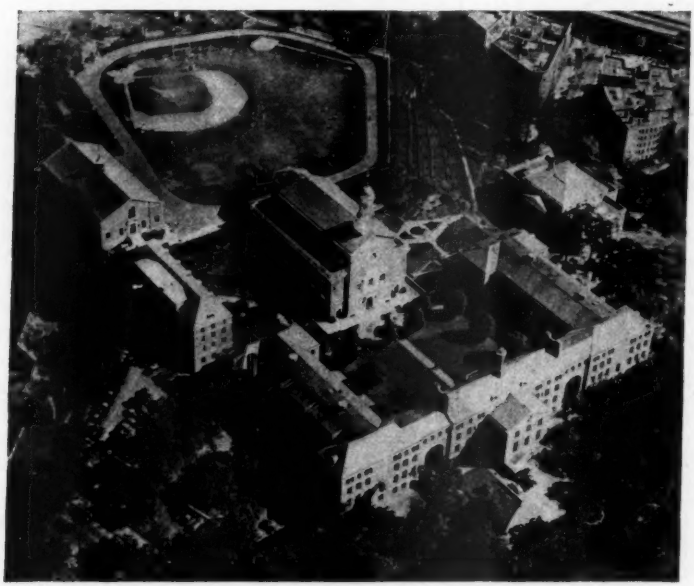
In addition to its student activities, The Cooper Union has long been an adult education center. Nearly 75,000 persons each year attend the free public forum meetings, an outgrowth of the lecture series started by Peter Cooper in 1862. Famous among early scientific lectures were those of John Tyndall on light, a series of six delivered in December, 1872. Today, outstanding American educators, scientists, and philosophers speak at the forum, which is held in the Great Hall every Tuesday, Friday, and Sunday evening throughout the winter. Supplementing the lectures, and also given free, are evening extension courses for adults in history, political science, music, public speaking, and other non-technical subjects.

The Cooper Union Museum, open to the public from 9 A.M. to 10 P.M., Mondays through Saturdays, has one of America's most extensive collections of the arts of decoration, arranged primarily for the purposes of study and research. Supplementing the collection is a special library of books and pamphlets on fine and applied arts and crafts, and more than 500,000 classified clippings and photographs of art objects. The Museum holds a number of exhibitions during the year and is used continually by not only Cooper Union students, but by many professional artists and craftsmen, who use the art of antiquity as a basis for modern designs.

The Cooper Union Library is divided into student and reference libraries and the Main Reading Room, which was dedicated by Peter Cooper to the working man and woman. The Main Reading Room was the first large public reading room in this country, and is the only remaining one in New York City today where the general public may read current out-of-town newspapers and periodicals. The newest public service added by the Library is the Defense Training Information Center, established a year ago to assist persons seeking data on schools where they may train themselves for specific defense jobs. More than 500 educational institutions in the New York metropolitan area use Cooper Union as a clearing house for the latest information on defense training. Adjoining the public reading room is the Humanities Reading Room, where engineering students, required at Cooper Union to take courses in the humanities, meet in informal seminars and discuss art and literature. On exhibition in the room are changing displays of antique and modern art, assembled by The Cooper Union Museum and the Metropolitan Museum of Art.

MANHATTAN COLLEGE

Manhattan College, with origin extending back 92 years, is situated on Spuyten Duyvil Parkway on the heights above Van Cortlandt Park, at 242nd Street and Broadway, New York City. It is a short distance from the Seventh Avenue Subway and can easily be reached from any part of the Metropolitan or suburban areas. It is a Catholic College conducted by the Brothers of the Christian Schools, a teaching order of the Catholic Church, and dedicated to



MANHATTAN COLLEGE.

the education of young men. Degrees are offered in Arts, Science, Engineering (Civil and Electrical), Business Administration, and Physical Education.

In 1849, four Brothers opened their first school in the Metropolitan district on Canal Street to accommodate a group of French settlers. Four years later this school was transferred to a site in Manhattanville, which later became Broadway and 131st Street. In 1863, the College was incorporated under its present title by the University of the State of New York and empowered to confer degrees. In 1921, the construction of new buildings was begun on

the present site of the College and complete transfer was made to these buildings in 1923. Since that time a chapel, gymnasium, dormitory and new library have been erected. The library building, known as the Cardinal Hayes Library, was erected by the members of the Manhattan College Alumni Association to commemorate the Diamond Jubilee of the College, and was dedicated in 1937. All of the buildings are in the stern simplicity of the Georgian style of Colonial architecture.

The Engineering School, which plays a very significant part in the academic life of the College, was established in 1889 by one Brother Cesarius Paulian, a man of broad experience and scholarship. Before embracing the religious state he had been professor of Engineering at McGill University, and later, Chief Engineer of the Missouri Pacific Railroad during the period of its construction. From 1893–1916, the Dean of Engineering was Brother Potamian (Dr. Michael O'Reilly), a physicist of international reputation. Under the direction of its present Dean, Brother A. Leo, Manhattan's School of Engineering celebrates its golden jubilee in 1942. The first class in Civil Engineering was graduated in 1892 and the first class in Electrical Engineering as recently as 1939. This school has a total registration of 310 students.

THE CIVIC MORALS OF SCIENCE

By CLEMENT C. WILLIAMS

President, Lehigh University

So frequently do statements appear to the effect that education in science and technology must have an infusion or leavening of the liberal arts in order to be beneficent rather than malevolent influences in civic morals that I am moved to inquire concerning the validity of the premises on which the statements are founded. Are they merely ghostly reverberations of Aristotle's disdain for manual skills still haunting the relics of the trivium and quadrivium? Are they rearguard actions of the battle waged in academia in the last century when science sought entrance at classic portals? Or are they actually footed on the natural effects of learning on human character? Without wishing to derogate any branch of knowledge, or to seem controversial, I should like to focus the inquiry on a few typical areas where the moral values of learning may be expected to be manifest in order to discern whether humanistic studies have actually a more beneficent effect than sciences on civic conduct. Does the one branch of learning produce better citizens than the other?

That much of the present world confusion results from a disparity of progress in science and in human relations would be generally admitted, and the exigencies of war have thrown that disparity into high relief. Within recent years, George Bernard Shaw, Rabindranath Tagore and the Reverend Dean Inge have charged technology with responsibility for disturbing world equilibrium and have even expressed a desire for a holiday in scientific discovery. In a recent letter, an eminent publicist asked whether, in my opinion, it would have been better if the airplane and certain other machines had not been invented, apparently wishing the race to live in a sheltered Eden out of reach of knives and other devices with which it might harm itself rather than to be developed through their use. Numerous voices have advocated a partial replacement of science with humanities in the curricula of engineering colleges in a belief that the hiatus between technology and ethical attainment in human relations might be closed from one side only. Some humanists have labored a tenuous distinction between "education" and "training" ascribing the former to letters and the latter to science, as if the disciplines of the one had properties of trans-

ferability not possessed by the other. As the argument runs, technology is supposed to be related to things and in consequence to have mineral morals while the liberal arts pertain to ideas and to life, and hence to be endowed with human and social values. One writer labels these two end products as "knowledge and wisdom, or in other words, science and values." This view apparently is based on the tacit assumption that language is not an acquired but a naturally inherited characteristic. There seems to be a vague superstition about its hidden origin through the breath from within the body which links language with the soul. Are words of air formed by the carnal mouth more divine and less man-made things than are tools of steel made by the hands? Both are implements. Both represent ideas but neither is an idea. An idea may embody sound judgment even if unexpressed verbally; it may be expressed by practical execution. A holiday in the production of verbiage would be fully as serviceable as one in the invention of devices toward locating the source of social confusion, which indeed results chiefly from the babel of academic voices attempting explanations.

Any implication that the motives of a scientist, even if diabolical, might somehow be transmitted to his inventions and thus influence their moral effects does not call for serious argument. The laws of nature are too immutable to partake of the personality of the one who reveals them. A monk of the church was reputedly the first maker of gunpowder, and Nobel, the engineer who invented high explosive, was a pacifist who gave the resultant fortune to promote peace and the arts of peace. The inventors of the airplane, sons of a clergyman, were the mildest of men; politicians, not the inventors, determine whether mail or bombs shall be the cargo. Of the responsible statesmen of recent years who have been unable to find a way out of international rivalries except through "blood, sweat and tears," none were suckled by the wolf of science. The most humane president ever to occupy the White House was an engineer. The engineer-statesman, Cavour, preferred diplomacy to war as a national policy. Da Vinci, engineer-artist of his time, in his famous letter to the Duke of Milan, offered to build engines of war and works of industry for a livelihood, but he painted that masterpiece of feeling, The Last Supper, from choice. Inventions are functions of nature's law and hence are independent of the inventor's character except as he himself employs them.

Fidelity to duty does not result to a less degree from the accuracy and objectivity of the sciences than from the subjective and a priori dialectic of the humanities. A few years ago, a colleague of mine on the faculty of a state university was employed to do some engineering work at the state prison. Being in need of an assistant after arriving, he sought an engineer among the prison-

ers. Not one was on the prison roster, although lawyers, bankers, teachers, preachers, and other representatives of humanistic callings were available aplenty. My curiosity being aroused, I made inquiry and learned that a similar situation prevailed at the penitentiaries of the neighboring states. The corps of army engineers, who have had charge of most of the construction operations for the Federal government for over a century, cherish the proud record of no defalcations in that entire period, notwithstanding the immensity of their financial responsibilities. These instances illustrate the observation that a betrayal of trust has been comparatively rare among scientists and engineers.

The precisions and rationalities of science yield a sense of moral direction quite as definite as do the emotional vagaries of literature. The recent brutal aggressions of dictator nations are recrudescences of the tribal barbarities and perfidies depicted in the Iliad, the Aeneid, Caesar's Commentaries, the Book of Judges, the Nibelungenlied and other classics which have been standard texts in arts courses for centuries. Language can be employed to deceive, to incite to crime, and otherwise misused quite as destructively as can nitrocellulose and the airplane. Perhaps the chief lag in social instrumentalities is language. It does not afford a vehicle for conveying thought unequivocally even between co-linguists. Indeed through striving for overtones and picturesqueness, language seems to be losing rather than gaining in exactitude. The use of words as sonic notes to produce impressionistic effects, permitting the appended ideas to dangle into a tangle, after the fashion of a modern school of writers, is a disservice to understanding. Grace of expression does not validate the sentiment contained. On the contrary, where correctness and precision are subordinated to felicity of phrasing, fallacies may be rendered less apparent by the lulling effect of a lingering assemblage of words. How many faulty maxims of life are treasured because of their euphony! How many speciosities have persisted because some superficial poet chanced to sing them! As exemplars of life patterns, the malodors of Shelly, Keats, De Quincy, Wagner, Poe and others compare unfavorably with the Spartan rectitude of the great scientists. Michael Faraday's ingenuous love letter to Sarah Barnard which closed, "As I ponder and think on you, chlorides, trials, oil, Davy, steel, miscellanea, mercury and fifty other professional fancies swim before me and drive me further and further into the quandary of stupidities," won him a devoted wife until "death did them part," while Byron's magniloquent epistle closing "My destiny rests with you" won him a mistress for only two years, when he deserted for other destinies. Linguistic facility may supply more abundant and varicolored verbal wrappings for a kernel of idea, but the "yea" or

"nay" or decision is not of the wrappings. Leaning, either liberal or scientific, can afford ethical standards only at the level of character, conscience and conviction.

Does one find an ethical or civic guidance in the methodology of the social studies superior to that inculcated by the systematic observing and testing of the scientific method? At the outset, confidence in the guidance of the former is undermined somewhat by two circumstances, viz., their conclusions are usually qualified instead of definite, and, secondly, scholars of equal standing in the field hold antipodal opinions relative to identical issues. Because circumstances are never repeated, history is only suggestive of possible outcomes of future events—evidence but not proof. Von Treitschke and Mommsen as historians arrived at the thesis of a super-race through the same egoistic predilections which led the psychopathic Nietzsche to the tenet "that the strongest and highest will to life does not find expression in a miserable struggle for existence, but in a Will to War, a Will to Power, a Will to Overpower." Across the Channel, historian Froude allowed his anticlerical prejudices to distort his judgments beyond trustworthiness. One reads volumes of history without a sentence which signifies discrimination in moral values. Political sway and military conquests are the crowning glories recognized for rulers and nations by the awards of written history. "The Great" is attached to Alexander, Catherine, Frederick and other predatory tyrants while "The Good" is applied to Charles, Phillip, and similar unimpressive sovereigns, and to them chiefly because of private kindnesses rather than political virtues. The realistic debunkers have sought to erase the peaks of individual inspiration and to level the narrative to a drab average humanity. Changes in fashion in historical viewpoint have been too frequent to impart a sense of established morals. Philosophies of history have been an adaptation of the biological theory of struggle and survival of the fittest with "the fittest" undefined except as the most viable. Their authors have overlooked the great biological principles of symbiosis and coöperation as factors in social and political development as well as the dynamics of a controlled psychology in national behavior. History's look is backward, while civic morals require a forward view. Was the treaty of Versailles overladen with historic hates? Would it have been more enduring if it had envisioned a future world of unexplored frontiers in scientific discovery where rich and limitless areas in human welfare await colonization? Will the ensuing treaty of World War II again only attempt to put new wine in old bottles? While we may be encouraged by the tendency of modern historians to devote more attention to the forests of common quests and advances of the race and less to the trees of nationalistic ex-

ploits, we are compelled to conclude that history has not attained complete clarity of ethical direction.

The claims for formal courses in politics and government as specific preparation for good citizenship are not supported by exhibits of products. The subject matter offered generally pertains to governmental structure and is seldom applicable to the issues to be marked in the voting booth. It does not offer a control of extra-legal cliques and pressure groups. Fluency in discussion of political affairs which rises from a knowledge of historical precedents must not be mistaken for good citizenship, for it may not even be its label. Tailormade courses in citizenship usually are little else than indoctrination. Political academism, by emphasizing popular participation in governmental processes at the expense of efficiency, has contributed to the lag of progress from ruralism and isolationism into an urbanized society and an integrated world economy. Its idolatry of political processes, oblivious of human limitations, has loaded government with detail functions which transcend the potentialities of governmental machinery. The design approach of technical education, which stresses practicalities, constitutes a proper balance to these ill-advised tendencies.

Does the "transcendental knowing" of philosophy or metaphysics afford a more definite and reliable comprehension of public affairs than does the observational approach of the scientific method? In philosophy, a layman discerns no cumulative attainment toward a firmament of truth whereas science does yield a consciousness of certainty in its peculiar realms of knowledge. Philosophy seems to the laity too much a pendulum swinging back and forth to afford an awareness of established direction. The philosophers of the ancient world ranged the gamut of theories of social and political organization and their successors have chiefly devoted themselves to an inconclusive elaboration of intermediate themes. Herbert Spencer, an engineer turned philosopher, in keeping with his time, viewed social ethics from the standpoint of materialism, but the fashion swung to mysticism and idealism when materialistic atheism was found to be an intellectual and spiritual cul de sac. Nietzsche's doctrine that might is truth and right and James's pragmatism that whatever works well is truth equally eliminate from the scheme of things a concept of ultimate right and truth. Both would justify Hitlerism if it works well, although James would have denied this. To use Will Durant's phrase ("Story of Philosophy") "Philosophies so cancel each other into zero" that they do not gather directional momentum.

In contrast, science advancing from one foothold of certainty to another is conducive to a positive faith in an ultimate truth that is

more stabilizing and constructive than the cynicism which is so frequently the product of actionless thinking and untested dogma.

Is there any reason to suppose that speculating on the nature of man and society, perhaps the most disordered phenomena of all creation, will inspire a more just ethic than does observing the constancies of the physical universe? Does emotional human caprice yield a nobler freedom than does harmony with fixed natural law? If one were permitted a generalization, it would be that education in the humanities finds its motif in the free development of the natural individual to the neglect of order in society, while education in science is of the essence of system and organization. These two vital principles in education, liberty and order, are inherently opposed to each other, but they are not necessarily incompatible, since liberty may stop short of anarchy and order may not reach regimentation. They are, however, the specific characteristics of these respective educational methodologies, the one relying on intuitive reactions, the other on factual ratiocination. Too much emphasis on self-expression without self-discipline may militate against social accommodation. Liberals and radicals gravitate to the one group while conservatives predominate in the other. The humanities emphasize individual freedom in education, ignoring its corollary confusion, even though competence and efficiency in government are the painfully obvious needs. Exaggerated attention to initiative of leadership may overlook the virtues of discriminating followership, which indeed may be the actual stepping stone to leadership. The voice of order must be heard in counterpart to the voice of freedom if good citizenship is to be of a nature to yield the social stability which we call civilization.

Good citizenship, like charity, begins locally, and has as many aspects as there are interests of men. Suffrage is only one of its many obligations. The college bred may be assumed to know its fundamentals. The growth in urbanization introduces into civic morals those physical instrumentalities of the technical realm which promote community health and social intercourse. Good administration, which is dependent on practicalities, is as important as legislation, primarily a function of political ideology. Popular balloting is less efficacious than business competition in picking executives to direct economic affairs, hence, instruction in any socialistic theory which unduly emphasizes political agencies of management does not lead to sound administration. "If to do were as easy as to know what were good to do, chapels had been churches" and sociology, the citizen's guidebook. Administration depends chiefly on knowing men, and as Vivian Grey said, "we do not learn men from books." In practical affairs both social studies and science must be supplemented by a knowledge of men and of

circumstances, and although they approach the problems from different angles there is no evidence to show that the former as a methodology is superior to the latter.

In a sanguine moment, one might assert superior moral values for science in education, but a safer postulate would be that purpose, the still small voice of the spirit, does not emanate from knowledge alone, either scientific or humanistic. Attitudes and motives are too egocentric to derive from external origins and too vital to be engendered by inert book lore. Practicalism is a proper and necessary counter-balance to idealism. Such qualities as honor, commonsense and good citizenship are not taught by courses but are instilled by a communion of personalities. Character and ability in teachers are essential and scientific subject-matter will serve as well as the humanities as the "carrier current." Engineering education is aimed at producing good citizens who earn their living by "diverting the forces and materials of nature to the benefit of man." Therefore, while I would include in engineering education as much liberal learning as accommodating the sciences will allow, I should do so under no misapprehension as to its superior civic morals but rather in order to round out that education into a symmetry of understanding and harmony of feeling to enrich life's satisfactions. The warp of scientific realism is no less essential than the woof of humanistic idealism in the fabric of civic morals for an advancing organized civilization.

THE ENGINEERING PROFESSION AND THE STUDENT *

By CHARLES F. SCOTT

Emeritus Professor, Yale University

A few days ago I asked a veteran professor what an S. P. E. E. section is for. He replied: "A nice time; to swap stories and gossip as to what is going on; to give deans a chance to tell what a good job they are doing; what sections ought to do is to consider some of the real problems of education." Today we have had a nice time; the deans did not glorify; you have discussed real problems.

My friend's curbstone snapshot reveals your new section as a many-purpose implement. Sections themselves are relatively new. Engineering schools multiplied prodigiously following the Land Grant Act of 1862 and thirty years later engineering teachers joined in S. P. E. E. Through free discussion of ideas and methods this voluntary group has, without authority save its own quality, been a dominant factor in engineering education. After a few decades came the geographical section—a further example of our American methods of voluntary coöperation and local group action. Our national engineering societies have had a vitalizing development through their local sections—bringing society activities home to the individual member and initiating action suited to local conditions.

While the analogy is not complete, our S. P. E. E. sections are bringing together teachers who do not get to the annual convention. The interest, fervor and quality of section meetings that I have attended are of first rank. From some has come the exhilaration of a national convention—a sort of contagious spirit of earnestness in engineering teachers which gives confidence and comradeship.

A section meeting separates from daily routine and gives opportunity for a perspective view of our work and our objectives. I would like to take such a view now, and to talk about some of the things which have become my hobbies. If I seem too much to talk about what I have been doing in E. C. P. D., please bear in mind that it is presumably because of these experiences that I am here rather than ability to polish plausible platitudes.

* From an address on "What Your Section Can Do" at the first meeting of the Upper New York State Section of the S. P. E. E.; Syracuse, December 6, 1941.

Just what are we trying to do? What are our objectives, our responsibilities in Engineering Education? As I see it there are two—two that I want to talk about.

I. The Individual Student

The first is the Individual. The "Aims and Scope of Engineering Education" have been set forth by our Society in a notable report. It is now the task of faculties to fit this program to the individual and vice versa. The student is to acquire knowledge and gain facility in its use. Stems carrying the sap for scientific-technological growth must intertwine with those of humanistic-sociological growth to produce a symmetrical tree of professional life. Prescriptions for doing this, in whole or in part, will be found on nearly every page of our proceedings. I am resisting the temptation to amplify. But, after all, too many teachers are complacently confident in their own ability without benefit of counsel.

II. The Engineering Profession

The second responsibility of engineering education is the Engineering Profession. This is something new if we use a century-long yardstick applicable to the traditional professions of law, medicine and divinity. It has come with modern science and technology and education, with new industrial and social and economic conditions. As these factors change, engineering through action and reaction with them changes also. It is not static; it is in active evolution.

I am regarding the profession as embracing the general characteristics that we ascribe to the older professions. I think it likely that each of us feels that he has a basic notion of what a profession is and of the engineering profession—quite satisfying until we try to make definitions. The intelligent public has profound respect and awe for engineering achievement, and when crisis comes it looks to engineers for new miracles. It assumes a unified professional group with special abilities of vital concern to progress and to public interest. Let us, for the present, regard our engineering profession in this light, forgetting our actual subdivisions and organizations. Just as the ideal of engineering education transcends the individual institution, so the ideal of the engineering profession transcends the individual society. Just as in the Church many denominations find useful fields for coöperation through its Federal Council, so in engineering the several societies achieve common objectives through its E. C. P. D.

The Student Today and the Profession Tomorrow

A professional group is composed of individuals. The engineering profession of the future must be recruited from the students of today; its quality will be the fruition of present-day student ideals and attitudes. Hence, students should have an understanding of what a profession implies beyond mere technical competency; they should understand what engineering contributes to our modern ways of life and the responsibility of engineers as a competent group of intelligent citizens in shaping the future.

Student Ideas of the Profession

In the E. C. P. D. report of 1940, the Committee on Professional Recognition (of which I am the chairman) notes the following incident. "Ideas of the profession are vague. In a talk to engineering students our Secretary asked how many expected to belong to the engineering profession. All hands went up. He then asked how many had a clear idea of what a profession is or could define the engineering profession. Not a hand was seen. They were diligently preparing for something but apparently did not know what it was."

The corresponding report for 1941 contains this incident: "Mere engineering employment does not signify professional status. The chairman of a state registration board says that he took little interest in codes of ethics until he made an investigation. He interviewed half a dozen graduates in his company's service who came from leading institutions. With one mild exception he found that no one seemed to have any idea of 'professional' relations or obligations or codes of conduct. His attitude changed. He now advocates that students should acquire a basic realization of professional attitudes and obligations and conduct—a sense of professional consciousness."

The Committee a year ago urged on our societies "that their student groups be encouraged to become informed and interested in a study of engineering as a profession including its present status and its development; also, the field of professional ethics." There are now about 500 such groups of future engineers in training.

Members of the committee are taking up the matter with the several societies. I have pointed out in a letter to student branches that their purpose is to help students, aided by affiliation with a national professional society, to become broad gauge engineers; that it gives them opportunity for their own initiative in doing what they choose; that curricula and professors' grades have particularly to do with their technical preparation, but personal and

professional development is their own responsibility and to this their branch may contribute much.

The following is cited for their contemplation. "Engineers reach the limit of their usefulness from defects of character rather than from want of technical attainments. Our greatest difficulty is to find courage, candor, imagination, large vision, and high ambition. H. G. Prout."

Wickenden's "Second Mile"

Students are looking ahead to professional status. Just what does this imply; just what is the engineering profession? As an ideal and as an actuality? As a "unified professional group" and as an aggregate of separately organized societies? What are the relations for instance between engineering graduation and technical employment and engineering society membership and engineering registration? Happily a clarifying survey of engineering in its professional aspect is presented in an address by President Wickenden to the Engineering Institute of Canada entitled, "The Second Mile." "The second mile . . . the mile of voluntary effort where men strive for excellence and may attain to the dignity and distinction of a profession, which lies beyond the first mile of compulsion." President Wickenden has revised this address at the request of E. C. P. D., with a view to its reaching student branches.*

The Teacher's Responsibility for Professional Understanding

The Committee on Professional Recognition also urges "that engineering teachers make a study of the historical development and present status of engineering and its interrelations with modern life, and endeavor to develop in teacher-student relations and in student life, habits and relationships in harmony with professional codes of conduct." (E. C. P. D.'s new "Engineering as a Career" contains pertinent material in text and references.)

Student development is the sum total of many processes. The teacher imparts by precept and by example. His pronouncements are made effective by his own methods of thinking, his own attitude, his own way of life. The visiting engineer may talk of work done or of codes of conduct but the impression he imparts is himself, his own competency and character. What really counts is what the student acquires through his own interest and active assimilation. Maybe professional relationship like culture, is not a course to be taken but rather an attitude to be cultivated.

* Copies available at E. C. P. D., 29 West 39th St., New York, N. Y.

"Ethics" may imply not merely canons to be passively learned, but rather a dynamic quality in a life to be lived.

This little dissertation presents no program to be followed, but a general objective to be attained. I wish this subject could be explored to determine what is being done by societies, by schools, by teachers, by students. How do our most effective schools and teachers get results, both by formal and informal methods? What do engineers, those a few years out and those long in practice, think about it—about the other-than-technical phases of the engineer's life? What ideas did they get in school; how did they get them—by memorizing precepts or by the example of individuals or from the experience and attitudes of college life? And what do they think should be done now?

An initial inquiry of this kind was instituted by Secretary Davies of the A. S. M. E. (see E. C. P. D. Report for 1940). The society by-laws promulgate the following society responsibilities: "fostering among engineering students the study of philosophy and history, tradition and achievement, duties and social functions of the engineering profession." Inquiry was directed to schools having A. S. M. E. student branches asking whether the ethics of the profession are discussed and by what procedure. Returns showed that in 49 of over 100 schools presentation was made in one or more of three ways; in course, 39 schools; in lectures by practising engineers, 24 schools; in student branches, in 21 schools. Other schools reported that various codes of ethics are posted; references are made to the honor system and self-government; ethical practice is implied but no formal consideration is given.

This preliminary study was restricted by the words "teaching" of "ethics." A broader investigation might well be undertaken by the societies and possibly with greater immediate effect by individual schools in a survey of what they are now doing.

Incidental and Other Ways of Teaching

A few weeks ago I attended the A. S. C. E. convention in Chicago to present to section delegates Relations of the Local Section to E. C. P. D. Later in the lobby an engineer from Los Angeles asked me if I knew Professor Swain. He said Swain gave a three-minute prelude to his lectures. In one he discussed knowledge, its application, and judgment; "the first you are getting now; the second you will get after a while, but judgment you must have all the time." The student recalls the prelude better than the lecture.

This recalls a reminiscence by another Swain, Phil Swain, now editor of *Power*, regarding Professor Breckenridge, my long-time colleague. The professor put on the blackboard the formula for

the heat required to make a room comfortable. To the conventional terms he added a + J. "What is that for?" the puzzled student asked. "Why, that is Judgment." Breckenridge was a great teacher; like teacher Swain his incidental lessons were lasting.

One encounters many views as to presenting professional obligations and "teaching ethics." One proponent of professional uprightness maintains that the golden rule is all that an engineer needs. He might have added that the principles of physics are all an engineer needs. But is application automatic?

I asked an engineering school executive what they gave the student regarding the professional phases of engineering. He explained that they did a very good job; the freshmen got it right away in a lecture. "And after that, what?" He hesitated a bit and then said engineering was not like medicine which was definite and unified; its students had a professional consciousness which engineering students did not have; it was too bad. I asked whether the restricted field of medicine could be a model for the broad and varied field which confronts engineering graduates. When I asked whether the students got other ideas besides the un-medical character of the engineering profession, I got no clarifying response. It will be the Blind leading the Blind, unless many of our engineering teachers get a new conception and realization of what the engineering profession implies.

Joint Action by Engineers

The urgency for professional "joint action" by engineers was proclaimed by the chairman of E. C. P. D., R. E. Doherty, in "E. C. P. D. Should Look Ahead" (Engineering Education, April, 1941). It is reiterated in his address before the annual meeting of A. S. M. E., December 1 (*Mechanical Engineering*, January, 1942). The first paragraph reads:

> At the annual meeting of the American Society of Mechanical Engineers in 1966 someone will present a paper on what has happened during the twenty-five years since the United States entered World War II. It may recite how engineers, along with professional men from other fields, broke away from their traditional attitude of professional self-sufficiency, stepped into the rapidly widening breach on the social and economic front, and helped to save America. Or, it may recite how engineers, along with other professional men, kept their eyes so steadily focused on status quo, clung so tenaciously to their traditional and interesting business of giving the country a technological joy ride, that they completely lost sight of facts that were vital. They forgot that they were, after all, living in a democracy; they overlooked the fact that if the people do not determine policy affecting their welfare, democracy must vanish; they did not recog-

nize that the activities and interdependence of groups in the national community had become so complex that the nation could no longer entrust its destiny as completely as in the past to emotional oratory and ignoble politics; they forgot that society had given them the privilege of higher education, and thus presumably greater competence to struggle with problems, and that therefore they had a commensurate responsibility for active interest and leadership. They lost sight of these vital facts. In other words, that paper—if indeed one can be given at all in such a case—may accuse our generation bitterly and with justice. It may say, "These men took things for granted. They forgot that they were trustees. They let us down. They forfeited freedom."

And what will it say of those engineering teachers who turned out engineering technicians without understanding, interest or attitude as to the obligations of the profession?

Timeliness of "The Second Mile";* A Letter

"Should 'The Second Mile' be presented to war-distracted students now?" My answer is, Yes.

The very fact that these boys are intensely occupied with war makes it all the more important that they get a long-range view of the stable foundations of a professional career. If we do not create a conscious bond with the profession and its ideals now or if we allow these ties to be snapped by war activities it may be very difficult to recreate them when the young men return to peacetime careers.

A physician comes out of interneship and goes into the forces. He realizes he is on loan to war effort; that he has not abandoned his profession. He is "on loan." We should have a parallel among engineers. Anything that can be done to strengthen professional consciousness now should be done. The young engineer has a long time to spend with his profession and only a short time to lend to the government.

(Signed) W. E. Wickenden

February 6, 1942

* *Copies* of the revised address may be obtained from ECPD, 29 West 39th Street, New York, N. Y., at 10 cents each, or 5 cents in quantity; further reductions in rates by the hundred.

ANALYSIS OF EDUCATIONAL SPEED-UP PLANS

By L. E. GRINTER

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We have just witnessed a great change in the attitudes of educators throughout the United States. The educational speed-up has been adopted, at least in principle, by many of our greatest universities and it is expected that a large percentage of all institutions will follow with some plan of acceleration. The phrase "in principle" is used because most plans have been optional paper plans which may ultimately be found to have served only as gestures. The final test must be whether a large percentage of the students in any institution follow the plan and actually graduate at an earlier date than normally. It probably can be accepted that earlier graduation without sacrifice of basic educational objectives would be a contribution to the war effort. Certainly, the armed services and our war industries will applaud the early graduation of engineers, chemists, and physicists.

An immediate contribution has been made almost universally by advancing the date of graduation in the spring of 1942. We found that we had been using time luxuriously and that a month could be cut off of the end of the second semester without serious damage. If our institution is typical, then there had been two weeks between semesters—one for examinations and the other for registration, including a brief holiday. One week has already been saved by giving examinations during the final classroom periods of the first semester and, similarly, a second week will be saved at the end of the second semester. In fact, we will save more than a week at the end of the second semester since Commencement is planned for the second day after the close of senior classes. In common with many other institutions, we had a spring recess and a junior week, with an elaborate "open house." In neither case was the entire week officially a holiday but, practically, the result was about the same. There seems little reason to question that during the seriousness of the war period there will be no great educational loss by shortening the overall length of our second semester a full month, along with the elimination of these vacation periods.

It is natural that universities should turn their next attention to the possibility of speeding up future graduating classes by use

of the summers. If the semesters are shortened to an overall length of sixteen weeks, three semesters can be fitted into a year. (The quarter system and the coöp term will be mentioned later.) The four remaining weeks will care for three annual registrations and allow for a Christmas vacation. At first thought, it all seems very simple, but, actually, there are several complications. Offhand, we can see that the present juniors could be graduated by January 1943, the present sophomores by September 1943, and the present freshmen by May 1944. After that date, we could graduate only one class a year unless there had been provision for freshman classes to enter the institution every eight months.

Although opinions will differ, there seems to be a serious question whether high school students should be encouraged to spend the summer in class. Army rejections are said to be high and in our large northern cities the youngsters' only opportunity for an out-of-doors vacation comes in the summer. The result of a general educational acceleration through the adolescent years might well have physical and mental debits. Hence, for most institutions, it seems probable that the speed-up plan as now considered for engineering is limited to the accomplishment of moving three classes ahead so that a full extra class of perhaps 14,000 engineers can be graduated by May of 1944.

This accomplishment cannot be considered negligible for it represents an increase of between five and ten per cent in the fully trained engineers engaged in purely technical work. However, it must be balanced against the loss for the sixteen-week summers of 1942 and 1943 of a large part of the sophomore and junior classes as engineering aids or junior draftsmen. Also, these long summers of engineering practice on the sub-professional level would do much to enhance the value of our graduates who must assume unusual responsibilities upon graduation. To some extent, the situation is comparable to a readjustment of coöp students from their usual five-year course to a four-year course offering less industrial experience. Certainly, present employers would not favor such a change, although it might possibly be a contribution to the total war effort if the immediate need for graduate engineers begins to overbalance all other considerations. This comparison also clarifies the fact that the problem is identical whether the institution operates on the semester system, the quarter system or the coöp system of short terms. Engineering practice experience will be sacrificed by the speed-up system now being considered.

Since the training of E. S. M. D. T. students has become a part of the work of the engineering schools, any plan of acceleration should be analyzed jointly with plans for E. S. M. D. T. summer

courses. During the summer of 1941, there were large numbers of defense students trained in the engineering colleges for periods of ten or twelve weeks on a full-time basis. Regular engineering teachers undoubtedly contributed greatly to this program during their vacations. The available period of sixteen weeks during the summer of 1942 can be used most effectively for work of a similar nature and this program can be of much greater scope if industry and government will aid the student by placing him on the payroll during the educational period. In fact, this plan, when extended to all of the engineering colleges and built up to require their full-time services, could produce 100,000 trained technicians during a single summer. It seems evident that there could not be a speed-up program for all engineering students and a full-time E. S. M. D. T. program of this magnitude conducted simultaneously.

There is also the possibility of increasing both the number of engineering aids and the number of graduating engineers by an earlier induction of high school students into the engineering college. At the end of the junior year of high school, both the adolescent period and the stage of physical growth are largely past and the student has had an opportunity to become interested in science and engineering. A reasonable number of such students could undoubtedly be encouraged to enroll for a special summer semester of pre-engineering study. It seems evident that in one summer semester in the engineering college we could produce as great an educational growth period from the engineering point of view as would occur naturally on the average during the senior year in high school. After completion of this preëngineering semester, these high school ex-juniors would be enrolled as regular engineering freshmen to swell the entering class. For such students the eight-year high-school-college program would be reduced to seven or to six years if succeeding summers were used. Apparently, the speed-up program to be most effective should begin with a pre-engineering summer semester.

It seems probable that the acceptance of students into liberal arts and commerce departments as freshmen upon completion of the junior year in high school is likely to become widespread. Such colleges are being severely depleted by the selective service draft and by industry's need for men. Every means is likely to be used to maintain enrollments—and this extends even into the graduate schools where college juniors are suddenly welcomed. Engineering colleges could assure themselves that standards of technical education would be properly maintained and they could still increase the number of engineering aids and of graduate engineers by use of the preëngineering summer semester.

It is important to look into the future for a view of the result of the speed-up upon engineering enrollments after the emergency. We will almost certainly return to the four-year program (unless we decide to lengthen it) because the universal use of summers continuously appears impractical. Many students will be unable to finance a continuous program even during the present prosperous period and they will have to be subsidized either by the institution or by government. When the college returns to its four-year program, the speed-up adjustment must be reversed. If the change is made at graduation in May of 1944, the then existing classes will have been in the institution respectively two and five semesters. The following fall there would be a class of freshmen entering upon a four-year program, a class of sophomores with three years to complete, and a mid-semester junior class. Of course, one class would not exist at all and the institution would have to subsist upon about 80 per cent of its usual income from tuition and fees. If a large number of high school students had been accepted into college as freshmen after completing the junior year in high school, we should also expect a reduced freshman registration for the first year of the readjustment. The return of service men to the colleges should compensate for the latter effect, but those wishing to enter as beginning juniors or seniors would find no regular group to join and it would prove expensive to accommodate them.

Since the losses of any speed-up plan are quite as evident as its gains, it is perhaps fortunate that a governmental action is necessary to put it into complete operation. The decision to be reached is whether war demands during the next two years for graduate engineers will be so critical that less mature graduates without the usual experience as engineering aids, but in increased numbers, would be more useful than the regular number of four-year graduates supplemented by well-trained E. S. M. D. T. technicians. Only those who have an inside picture of the needs of all war services could properly make the decision. That a uniform plan of acceleration is required cannot be questioned if the result is to be the greatest contribution. It is usually possible for any intelligent student to work on an irregular schedule through the summers and to graduate in three years. However, unless there are loans or subsidies available for the extra expenses involved by the student, it is only wishful thinking to assume that most engineers will adopt such a plan. The opportunities for summer employment in war industry will be so attractive that only a sense of duty or of "being with the crowd" will keep engineering students in school during three successive summers.

Perhaps the greatest contribution would be made by a speed-up

program for the present juniors. These men could be graduated in January 1943 when industry will be striving to attain its peak of production. After this maximum production is attained, it would seem that the usual flow of engineers for natural replacements might suffice. The faculty not engaged in teaching senior students during the summer would be available for full-time E. S. M. D. T. instruction. To hedge against a decreasing number of entering freshmen, because of the draft and the attractiveness of industrial jobs, we might seriously consider the plan of a preëngineering summer for present high school juniors so that our output would be maintained in the event of a long war. It is evident that a speed-up plan involving only these essentials could be operated at a much smaller cost to the engineering colleges than the full acceleration program that has been under consideration. But, unless our instructors are asked to teach summer classes without compensation (a particularly unpleasant prospect because of increased costs of living) any acceleration of the engineering curriculum will produce a burden upon the budget of the institution.

WRITTEN ENGLISH IN DEFENSE

By JAY R. GOULD

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Not so long ago a friend of mine, thinking no doubt of the more obvious contributions which engineering instructors might make to national defense, remarked: "You teachers of English haven't much to offer, have you?"

It so happened that a few days later I had the opportunity of talking with an army officer of long experience. I asked him: "Is English important in defense? Can it be used in the defense program?" His answer was immediate and positive, although in some parts unquotable. It left no doubt that the problems of faulty communication, both written and oral, as they affected the army, were very real. Faulty writing means misinterpretations, and misinterpretations result in a lack of efficiency; and efficiency in all its forms is vital to a prepared army.

English in its widest sense, as part of the educational program, is as important to the most beleaguered nation as it is to the most peaceful. It is an interesting paradox that in England the government is paying more attention to education than it did in peace times. In a recent bulletin occur these words: "It was soon apparent that a civilized nation, compelled to defend itself in war, must strive to the utmost to prevent the submergence of the most civilized elements within its life." And in speaking of Oxford University a correspondent writes: "In the war of 1914–18 the University was temporarily almost extinguished. Today the ancient citadel of culture is treated more tenderly and wisely. It has not been thrust aside, but conscripted as an important unit in the national effort."

It is as an important unit in the national effort of this country that we teachers should regard our profession. (This symposium concerns itself with English and Defense. We are here to examine our credentials.)

It is obvious and fundamental that written English in defense should start in the classroom. Once again let me quote from an English source as the authoritative judgment of a country that has had to learn by bitter experience. After becoming Prime Minister, one of the first official acts of Mr. Winston Churchill was to issue his famous order to the civil service calling for simplifica-

tion of official language; asking, for example, a substitution of a simple "Yes" for the official "The answer is in the affirmative"; requesting them to say "buy a book" instead of "acquire the work in question through the ordinary channels of trade." As a result of Mr. Churchill's emphatic demand the Manchester *Guardian* christened him "Jack the Jargon Killer."

This last, of course, brings to mind Sir Arthur Quiller-Couch and his famous essay on *Jargon*. It is interesting to note, I think, that so many of Churchill's pronouncements parallel examples found in that essay. In other words, the Prime Minister of England found it necessary to go back to and to rely upon one of the most fundamental concepts of our language, that words can be translated into deeds only when the words convey their real meanings, that verbiage should be abhorred, and brevity and coherency stressed as of the most vital importance. These are limits that first and foremost must be taught in the classroom, both in spoken and in written language. We should teach that English is our official language and we should insist that writing be hewn to the fine and exact line. Insofar as we here are concerned, I have only to refer to two special types of writing which meet the requirements and which are taught primarily at engineering colleges. These are reports and business correspondence. Dealing as they do with the presentation of facts, they demand an exactness of expression which proves valuable not only in the classroom, but in the world of business as the graduate finds it. We are told repeatedly by graduates that such writing provides excellent training in distinguishing essentials from non-essentials. Coupled with this, and quite as invaluable, is the training that report writing and business correspondence give in the field of public relations, a training which should mean as much to a society in defense where the interrelationship of groups is vital to the program.

Of what possible use can written English be to the armed forces of the nation? This question has still to be answered. It must be remembered that the army and navy are taking into their ranks great numbers of civilians, with the task of converting them into professional service men as rapidly as possible. The speed of conversion is extremely important, and the speed will depend, among other things, upon how well and how quickly the experts can explain the technical aspects of the service to beginners. Manuals of directions must be geared for these new members of the army. It isn't as easy as it sounds. Our friend, the army officer, who stressed the importance of English, was admitting the existence of red tape and circumlocution. In the present defense program, orders and directions must be transmitted to the raw recruit. Efficiency and time are the twin goals today. As teachers of Eng-

lish, we should be able to assist immeasurably, if requested, by examining these systems of communication and by suggesting methods for improving them. Bureaus of instruction may very readily use our services.

Today an army works not only from within but from without as well. The fall of certain European nations has brought one important fact to mind. The army must depend to some degree on the civilian population. Clogged roads of transportation, insufficient shelters, directions not carried out, these resulted from the civilians not understanding the demands of the army. Again the red tape must be cut through. Orders and correspondence must be understood by the civilians, and the army should understand the special problems of the civilians. Certainly a great part of this understanding will be achieved if each body recognizes the other's language. One of the great problems of the moment is the so-called bottleneck. A bottleneck can arise from faulty communication as rapidly as from any other source. From central army offices, instructions must be sent out, instructions which explain clearly just what is to be done, and arouse in the workers the earnest desire to do it. There will be letters written dealing with all sorts of problems—of management, of personnel, and of procurement of materials. The importance of written English to this phase of defense, this particular relation of the armed services to the civilian workers, arises from the fact that we teachers of English are teaching the techniques of communication. We should now expand outside the classroom and carry these techniques over into practical affairs. The problem of army communication requires as practical a solution as we are capable of giving it.

The modern army looks to the future as well as to the present. The modern soldier is no longer only a fighting machine. He is a man trained as a citizen as well as a fighter. His horizon is not limited to the business at hand. In many cases he has come from a civilian job, and it is to that job that he expects to return. In the meantime his mind must be kept active, he must keep up in his profession and his training, and his intellectual wants must be satisfied. It is here that one of our greatest contributions can be made; by sponsoring education in the army for all those who want it.

Writing, in all its many phases, can be taught by college professors and civil authorities. There is no reason why the red tape cannot be cut through and why we cannot help to prepare correspondence courses in writing and other units of English. It has been done in peace times; now we have an opportunity to help those who are temporarily away from regular schools so that they may still attain the fine careers after their days of soldiering are

over. It will be necessary to prepare syllabuses of courses, to write special textbooks, to give special examinations. Eventually will come a day when the temporary soldier returns to civilian life, to reconstruct his interrupted career. The all-out signal for defense and assistance in defense has been given by the President of the United States. We are as responsible as anyone else in seeing that the soldier's abilities are not allowed to diminish, that he is encouraged to help himself.

A few weeks ago, you will remember, Dean Landis was appointed Director of the Office of Civilian Defense, and the wheels have continued turning. An army of millions of civilians has been put in the field, an army far outnumbering the regular army. Here, perhaps, lie the greatest opportunities for instructions in written English.

I shall enumerate a few of these possibilities in detail. In the first place, with the machinery of routine being set up, here is an excellent chance to reduce illiteracy among our people. An illiterate person is prey for all kinds of subversive influences. Never before has there been a greater call for a welding process to knit the many groups together. There are still too many in this country who do not speak and write our nation's language, and with the great influx from Europe, an increasing number. If only to teach a common tongue and a common language of communication, the teacher of English will be of paramount use in the community. Night schools, extension courses, correspondence courses by the schools and colleges can cater to the obvious need. Then, too, just as in the classroom, the welding process can be made in its larger aspects, in teaching the elements of research and writing which make the citizen more useful to himself and to his community. This should be our first concern.

In the second place, it will be noted that certain duties of the civilian in national defense call for specialized treatment. In some cities these specialized instructions have been given: lessons under the auspices of the Red Cross, lessons in public speaking to help individuals to become leaders in their local circles. Public speaking denotes speaking, of course, but implies also a writing angle. In some places, bureaus of instruction in the preparation of speeches have been set up; the supply can be greatly extended to meet the new demand. Men are constantly leaving for the army; speeches must be prepared to show them their responsibility and the responsibility of the community toward them. There will be the increasing necessity for raising money so that the various private agencies of public welfare may continue to function; speeches must be written for these. There will be bonds to sell; the new Defense Bonds are a point in issue. One fact must be emphasized; that is,

the need for individual attention. Each community will have to handle its own problems in its own way. General directions must be translated into particular directions.

Because of this, it is apparent that in each community all the so-called public agencies will function overtime. Health bureaus, medical clinics must send out reports, letters, instructions which can readily be understood by the members of the community. Various women's auxiliaries must teach other women how to feed, clothe, and keep up the health of their families in this time of emergency. We as teachers of English will undoubtedly be called on, and we should offer our services to make this phase of communication as simple and understandable as possible, so that our individual communities can be geared to the highest possible action.

From the experience which we at Rensselaer Polytechnic Institute have had with the Institute radio station WHAZ, a third way of using better written English in defense comes to mind: the use of small local radio stations. Even though written directions will be sent out showing how the country at large should prepare for blackouts, deal with incendiary bombs, act as spotters for approaching planes, once again each community will have to deal with these problems locally. Names of local wardens, local bureaus, precise directions must be incorporated into these more generally treated directions. Radio offers a particular vital means of getting these across to the general public.

Specifically we teachers might put forth the following suggestions: (1) that the resources of local radio stations be utilized to give instruction to the community, (2) that in each community possessing a local station a bureau of script writing be set up, treating of the special problems of the community and using those writers who are aware of the special problems, (3) that the scripts present in dramatized form, rather than in lecture form, how the average person should act when danger threatens his community, what preparations he should make, what precautions he should take, and in what functions of local agencies and defense groups he might participate. One dramatic production is worth a dozen abstract treatments. Such a radio series will call on the resources of writers, and is a valuable way in which they may contribute to defense.

We may call it education, we may call it propaganda, but we know that above all the public must be awakened to a very real danger: the spreading information through harmless gossip. I will not attempt to speak of the problems of official censorship. However, one of the aims of the defense office will be to make each citizen a censor in himself. Such an awareness of the danger of spreading information may come through pamphlets distributed to

the reading public or through radio scripts as I have suggested previously. At any rate here is a field for the teacher of English which should not be overlooked.

In this talk, I have tried to show how teachers of English—especially teachers connected with written English—may contribute to the defense program.

First of all we must continue to train students for the future so that in years to come the general level of proficiency may be at least as high as it is now.

Secondly we can be ready to perform individually certain duties for the armed forces for which our professional training has given us special preparation—for example, in showing how to cut through official red tape, how to prepare form reports, and files of business correspondence in order to achieve the highest degree of efficiency.

And in the third place, each of us knows our community and the problems it faces. In the immediate future perhaps that will be our greatest contribution—in preparing manuals for local bureaus, in assisting local firms, and in writing scripts for dramatized presentations.

INTERESTING THE ELECTRICAL ENGINEERING STUDENT IN ENGINEERING ECONOMY*

By RUSSELL C. PUTNAM

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Thomas Alva Edison has his position of immortal fame in the annals of electrical engineering, but he still had a lot to learn about engineering economy. Dyer and Martin tell about it in their biography, "Edison: His Life and Inventions." When Edison and Orton were discussing the sale of the patent for the carbon transmitter to Western Union they came to the question of terms. Orton offered $100,000. In describing this later Edison said, "All right, it is yours on one condition, and that is that you do not pay it all at once, but pay me at the rate of $6,000 a year for seventeen years —the life of the patent. He seemed only too pleased to do this, and it was closed. My ambition was about four times too large for my business capacity and I knew that I would soon spend this money experimenting if I got it all at once, so I fixed it that I couldn't. I saved seventeen years of worry by this stroke."

Edison might have saved seventeen years of worry, but how much money did he lose by refusing the cash payment of $100,000? In those days 6 per cent seemed a fair interest rate so that will be used as a basis for this discussion.

True, $6,000 multiplied by seventeen is $102,000, but what about the time value of money? Assuming payments coming at the end of the period and 6 per cent interest compounded annually, the present worth of the seventeen payments of $6,000 each is $62,862 which represents a loss to Edison of $37,138 in present worth. Looking at it another way, Edison might have set up a seventeen year annuity which would have given him an annual payment of $9,544 instead of the $6,000 which meant that his choice resulted in an annual loss of $3,544. Or, most spectacular of all, if he had taken the $100,000 and put it at 6 per cent interest he would have received his $6,000 a year without diminution of principal indefinitely, or at least as long as that interest rate lasted. In other words, all Edison asked for was the interest on the amount offered,

* Presented at the 49th Annual Meeting, S. P. E. E. (Engineering Economy), University of Michigan, June 23–27, 1941.

letting Orton keep the principal. No wonder Orton seemed only too pleased to accept Edison's terms!

Just to show that he probably never did learn, some time afterward Edison sold the patent for the motograph to the same man. Again Orton offered $100,000 and again Edison insisted on $6,000 a year for seventeen years, relating with great satisfaction his business acumen!

To a group of electrical engineering students, familiar with Edison's inventions and the brilliance, painstaking care and rugged common sense of his technical accomplishments, such a blind spot in one of their patron saints is particularly amazing. After they get through making the previously mentioned analyses, checking their results by showing that the present worth of the annual loss of $3,544 for seventeen years agrees with the loss in present worth of $37,138 computed originally, figuring how the amounts would change if Edison chose to take out his money at the start of each year instead of at the end and having a little laugh at Edison's expense, they find that they do see some value in this subject of engineering economy. Generally enough arguments develop that by the time they finish this discussion they have a fairly good idea of the time value of money, compound interest, equivalence, the present worth of an annual series of payments, etc., and are beginning to get the idea that this course might be worth while at that for an electrical engineer.

In teaching any subject two things are essential. The first is that the subject matter be presented in a logical, scholarly and thoroughly adequate manner and the second is that the student be keenly interested in the work; so interested that he is mentally alert to follow every line of reasoning and to understand the subject as completely as possible. The awakening and continuing of such interest is, of course, also largely due to the method of presentation.

The fundamentals of engineering economy are the same for all branches of engineering and can be covered with the background of mathematics and economics that most students have at the end of their sophomore year. In order to get the most out of the course, however, and to understand it thoroughly, the author believes that engineering economy should be given in the second half of the senior year, where it can be used as a means of summarizing all of the separate and sometimes seemingly unrelated subjects of the college curriculum into the complete and integrated whole that is engineering; when it can use as background all the technical and practical knowledge that the student has gathered in three and one-half years, and at the time when the student is looking forward to his immediate contacts with industry and is in a particularly receptive

mood for a consideration of the economic side of engineering. Moreover, if possible, the instructor for such a course should be one who by experience and aptitude has a broad training in both the technical and economic functions of the particular branch of engineering in which the students in his class are majoring. In other words, a group of electrical engineering students are likely to be more interested and to get more out of the class if the instructor is an electrical engineer and is discussing the problems from his own observation and acquaintance. At Case, where engineering economy is a required course for all senior engineering students, those principles are used in all the departments.

To get and to hold the interest of a student in engineering economy requires a method of presentation that is based either on the student's own experience or on situations that are not too foreign to those experiences. He should be able to visualize the problem, see himself in the position of the man who must make the decision, and to appreciate what the successful solution of the problem would mean. For example, the electrical engineering student who is introduced to the subject of engineering economy by a consideration of Edison's problem can sympathize with Edison and can see himself making the same mistake, given the same opportunity. His interest in the subject will be much greater than if he covered the same material with illustrations of savings bank deposits, sinking funds, annuities and the like, none of which is based on his own experience and all of which tend to strengthen his preconceived belief; *i.e.*, that this is a subject for bankers or business men, but not engineers.

The material in this paper is based on several years experience in teaching engineering economy as a required subject to senior electrical engineering students. Since it is a required subject and does not sound technical, this question of interest on the part of the student is of real importance. A method of presentation combining text book assignments and carefully chosen studies has been developed to arouse and sustain that interest.

About fourteen years ago, one of our seniors wrote his thesis on the subject of power factor correction for a local factory in which he had worked during vacation periods. The conclusion of the thesis was that the economic return was not great enough to warrant the installation. About ten years later, this man, newly appointed chief engineer of the same company, repeated his analysis and found that changes in the power factor and load conditions of the factory, in prices of corrective equipment and in public utility rates made correction advisable. A certain amount of reactive kva. in the form of capacitors was therefore installed.

In order to give them the point of view of such an executive, the students are put in the place of the chief engineer, with the same information that he had: the load schedule of the plant, the average power factor, the cost of the corrective equipment installed and the public utility rate with its demand charge, energy charge, discount for primary metering and method of figuring demand for billing purposes in order to encourage power factor correction. They are also given the figure for the rate of return which the officials of this firm have determined should be met for new equipment of this kind. They must use their training in alternating current theory to compute the amount of leading reactive kva. which would correct the power factor to unity. In this particular problem approximately 400 leading reactive kva. should be added to give unity power factor. The yearly saving is figured as a per cent of the cost of correction not only for the 400 kva., but also for steps of 50 kva. and the results plotted on a curve. The questions then arise; should the reactive kva. giving the greatest per cent saving be installed, should the whole 400 kva. be installed if the rate of return equals or is better than that established by company policy, or should some other amount be used? To answer that, the per cent savings on the new increment of correction on each 50 reactive kva. are computed and plotted. The curves show clearly that, although the rate of return of the whole 400 kva. is equal to that required, the rate of return of the last three increments is below the arbitrary percentage fixed by the plant officials. The conclusion is reached then that each increment should be considered separately and reactive kva. installed only up to the point where the incremental rate of return is above the percentage required.

In the discussion accompanying the solution of this problem the various factors bearing on the economy studies for a new enterprise, public utility rate structures, and incremental costs and income are thoroughly brought out, as well as the idea new to some of them that the most economical power factor correction may be entirely different from the best correction according to the electrical point of view.

The question of public utility rate structures is an important one for electrical engineers. Not only does it bring out important basic ideas in engineering economy such as capacity and load factor, but it is important in its own right. Most electrical engineers work with rate structures, either as representatives of a utility company or as engineers for the companies which are purchasing and using the power. An understanding of the function of public utilities (both privately and publicly owned) in the industrial system, the theory of their regulation, and the various cost factors entering into the furnishing of power to different classes of cus-

tomers in different localities is a necessary background for the intelligent study of rates. Experience has shown that electrical engineering students are not only very much interested in the various rates available and the economic reasons—or lack of them—for the charges that they contain, but they feel that this is one subject that they should know from the standpoint of general knowledge as well as for technical advantage. Interest can be heightened by quoting from various reports and charts, such as those prepared by the Federal Power Commission, although the skill of the instructor is sometimes severely tested in keeping the discussion out of the political realm and on a sound engineering basis.

As an example of the problem of replacement of existing equipment consider a manufacturing company with a department using wound rotor induction motors on a manufacturing schedule that requires much operation at low speeds. Because of the poor efficiency of these motors at low speeds, the proposal is made to replace them by either brush-shifting, adjustable speed, alternating current motors or by direct current motors supplied by a motor-generator set. Data furnished to the students include cost prices for motors and control for the three systems, efficiencies and power factors at the various loads and speeds, depreciation rates, salvage values, taxes, insurance, interest rate on invested money and the complete power schedule. Various aspects of the economy of replacement are brought out by the difference in the present book value and salvage value of the existing installation, the different number of years use given by the three systems, etc. The students' background in electrical engineering is used to check the data on motor performance and efficiency and to discuss and evaluate such characteristics as smoothness of speed control, speed regulation, and other factors not appearing directly in the economic analysis.

Different fields in electrical engineering are especially applicable in illustrating particular problems in engineering economy. For example, the question of immediate vs. deferred investments is a very important one for public utilities and much has been written on that subject. The value of a thorough economic study of the location, size and equipment of a new substation in a rapidly growing community, or the number of ducts and cables to be placed under the paved street of a city is obvious to the student. That interest may be heightened by pointing out an example in the community where a mistake has been made in such an analysis with subsequent inconvenience and loss.

The most spectacular and far-reaching development in electrical engineering in the past three years is the fluorescent lamp. Much publicity has been given to the high efficiency of this light source

and great claims have been made of the economies possible by the use of fluorescent systems. An economic study of the situation by engineers is particularly timely because of this wide public interest. This is especially applicable in colleges such as Case, where the senior electricals have a very comprehensive course in Illuminating Engineering and are familiar with the operation and characteristics of the various light sources and the design of lighting installations.

Illuminating engineers of the lamp manufacturing companies, notably General Electric and Westinghouse, have been working on such cost analyses for the last couple of years and their methods are gradually spreading through the lighting industry.

A similar cost comparison has been worked out for the electrical students in engineering economy to use in dealing with the same type of problem and is attached as an appendix to this paper. It will be noted that it includes the complete engineering job of layout design and cost analysis; including consideration of the lighting equipment proposed, the illumination design, equipment cost, installation costs, annual fixed costs, operating costs, total costs and break-even points.

The design for lighting a large drafting room is particularly well adapted for such a problem, as good installations of both incandescent and fluorescent lighting can be made at the present time and there is some controversy as to which is preferable. The student first decides on the various types of incandescent and fluorescent lighting equipment that would be applicable for this purpose. The complete illumination design is then carried through for each type of equipment, resulting in a satisfactory layout from the lighting point of view using any of the proposed schemes. The choice now depends on the economic factors. The net cost of the individual units of equipment is first obtained and these are then extended to get the installation costs, including the wiring. The rates of capital return or amortization of the wiring and the permanent parts are then established and the annual fixed costs determined. Operating costs include the annual cost of electric service (depending upon demand charges, energy rates, estimated hours of use, etc.), the cost of lamp renewals and miscellaneous maintenance such as cleaning and the cost of replacing lamps. The total annual costs are then obtained and compared in this problem on an annual cost per footcandle basis, although other bases might be used, such as cost per million lumen hours. Two break-even points are determined: the break-even point in hours for the given rate schedule and the break-even point in energy rate for the given number of operating hours per year.

Incidentally, while the students were working on this problem some of them attended a sectional convention of the Illuminating Engineering Society where one of the major papers was on just this subject. That certainly brought home the fact that this was of immediate interest to engineers, but that is something that the teacher of Engineering Economy cannot depend on regularly.

In the illustrative problems throughout the course the student proceeds much as in the typical problems outlined in this paper, using the training he has received in the various engineering courses to solve the technical points of the problem and correlating the technical and the economic aspects to get the final solution. In the discussion the three criteria which the late General J. J. Carty of the American Telephone and Telegraph Company established with his famous questions, "Why do this at all? Why do it now? Why do it this way?", are considered from both points of view and their various merits evaluated. In all cases emphasis is laid on the fact that it is all engineering, whether the particular technique being used at the time was taught in a course in direct current machinery, alternating current circuits, or obtained from studying a text in engineering economy.

All the classwork should not necessarily pertain so closely to the electrical engineering field. After the student's interest has been aroused by problems and illustrations based on that particular branch of engineering, applications in broader fields can and should be made.

In securing the attention of the student, however, an indication that those who have reached positions of eminence in his own profession consider engineering economy important is of decided value. For instance, if the student should refer to the "Handbook of Outside Plant Engineering Practices" written by the American Telephone and Telegraph Company for their engineering personnel he will find that a large part of it is in reality a book on engineering economy, discussing the same fundamentals that he finds in his own text with particular emphasis on economic selection, and even carrying the same tables of present worth, capital recovery, etc., in the appendix, then he is convinced that this is actually engineering and as such is worthy of his interest and attention.

Show the electrical engineering student that engineering economy is an integral part of engineering, use it in problems along with his technical knowledge to prove that they are both needed for the complete solution, speak his language and base the illustrations first on his experience and then broaden his outlook, and the question of interesting the electrical engineer in engineering economy will be solved.

APPENDIX

Method of Cost Analysis

Design of Lighting Installation

A. Proposed Lighting Equipment			
1. Light Source (Incandescent, mercury, fluorescent, etc.)			
2. Luminaire Used			
3. Lumen Output per Lamp			
4. Life of Lamp in Hours			
5. Wattage of Lamp			
6. Wattage of Auxiliary			
7. Number of Lamps per Luminaire			
8. Total Wattage per Luminaire			
B. Illumination Design			
9. Room Dimensions			
10. Area of Room			
11. Ceiling Height			
12. Spacing of Units			
13. Mounting Height			
14. Number of Outlets			
15. Reflection Factor of Ceiling and Walls in Per Cent			
16. Room Index			
17. Coefficient of Utilization			
18. Maintenance Factor			
19. Average Footcandles			
C. Equipment Cost			
20. List Price of Luminaire and Auxiliary (If mercury is used, auxiliary should be considered separately)			
21. Discount on Luminaire and Auxiliary in Per Cent			
22. Net Price of Luminaire and Auxiliary			
23. List Price of Lamp			

APPENDIX—(*Continued*)

24. Lamp Discount in Per Cent			
25. Net Price of Lamp			
26. Net Price of Complete Unit			
D. Installation Costs			
27. Total Cost of Wiring			
28. Total Cost of Luminaires and Auxiliaries			
29. Total Initial Cost of Lamps			
30. Total Cost of Installation			
E. Annual Fixed Costs			
31. Amortization of Wiring Per Cent			
32. Amortization of Permanent Parts in Per Cent			
33. Annual Fixed Cost of Wiring			
34. Annual Fixed Cost of Permanent Parts			
35. Total Annual Fixed Costs			
F. Operating Costs			
36. Operating Hours per Year			
37. Monthly Demand Charge			
38. Energy Rate			
39. Demand Charge for Year			
40. Energy Cost per Year			
41. Total Annual Cost of Electricity			
42. Cost of Lamp Renewals for Year			
43. Miscellaneous Maintenance			
44. Total Annual Operating Cost			
G. Total Cost			
45. Total Annual Cost			
46. Annual Cost per Footcandle			
H. Break-even Points			
47. Break-even Points in Hours for Given Rate Schedule			
48. Break-even Point in Cents per Kw.-h. for Given Operating Hours per Year			

AN ABSORBING ADVENTURE IN TACKLING THE INTANGIBLES OF PERSONALITY *

By EDMUND D. AYRES

The University of Wisconsin

A student's interest, ability, and personality often serve as quite reliable guides to the particular field in which we expect him to seek success. There are, however, many students whose bent is difficult to diagnose. Some few students bid well to succeed in any field to which they may devote their future energies. The general attitude of the engineering college is to insist upon an adequate and sound technical training with the hope that the many forces still at work on the boy's personality will shape him sufficiently to make him merit success in the division of the field into which he is called after graduation. The requirement that each student receive a sound technical preparation meets with little dispute. Whether special courses in college would tune up the right graduate along sales or other special lines is likely to furnish discussion for some time to come. General agreement upon the value of such special courses is unlikely. Since these statements truly reflect the situation, a discussion of more informal procedures seems pertinent.

When the preliminary program for this conference revealed that my story was to fit under the subject of special training of engineering students for sales engineering, I felt perhaps the informality of our adventure might not live up to the letter of the assignment. From the human relation standpoint, however, I am convinced that our story does fill the spirit of the assignment adequately if we think of the broader aspects of training the student to sell himself and his services, that is to develop his personality.

The whole adventure is something about which I like to talk, yet, in discussing the exact content of what I should say here with one of the students who has shared in our efforts for several years, he remarked, "It is a difficult matter to discuss in an objective way, for we are dealing with how to live." Our effort started with the unique assistance of a very successful sales engineer. The goal was literally to awake the student engineer to the problems of human relations in industry and deliberately to do something about mak-

* Presented at the 49th Annual Meeting, S. P. E. E. (Electrical Engineering), June 23–27, 1941.

ing the student a better salesman of himself as well as a better man and a better engineer.

Special courses pointed towards sales engineering would likely be adopted for the development of skills. The more contact one has with the sales-minded student, the more one wonders if deferment of training for skills for an attainment of positive attitudes is not the real need. So often this kind of a student takes his engineering the hard way—with lack of real technical interest leading to insufficient application and mediocre performance. If this attitude in college could be changed and a healthy attitude toward human relations in general could be stimulated in him as well, would not he be better prepared for his future work in sales and even for the attainment of the skills that his calling will demand of him? Would not positive attitudes work miracles for every student? It is on this point that the goal of our effort broke its bounds and expanded to embrace the broader question of how to live and expanded to include in its circle even students preparing for other professions than engineering. Positive attitudes—how do you get them?

First, let us pick up a few high points roughly outlining the sort of principles and problems that form the nucleus of our group's attention and let us fit positive attitudes into a still broader relation. Melvin J. Evans, the management engineer, whose dream this effort really is, soon established the ideas * of unselfish action and "keeping on a keeping on" as part of the bedrock of the group's philosophy. As an expression of direction the following formula * is used:

Development of character
plus
Development of positive attitudes
plus
Acquisition of knowledge
plus
Direction of energy
equals
Growth and achievement

Greatest stress is placed upon unselfishness, positive attitudes, team work, and perseverance. Such matters as selfishness versus self-interest, the banishment of resentments, the importance of courage, the importance of reliability, the mechanism of habit change, and a host of other considerations are dealt with frankly and vigorously.

* See "Democracy in Action," a booklet published by Melvin J. Evans, Evans Associates, Inc., 307 N. Michigan Ave., Chicago, Ill., for a quite thorough treatment of principles and approach.

A recital of these things gives a measure of the size of the job attempted, now how is it done?

At the start, we strove desperately to walk right up to our objectives. Beginning in 1937 we started out with weekly meetings open to all. We listened to lectures, we reviewed selected biographies, we put on sales playlets, we staged sample interviews, we checked and re-checked individuals with personality and interest ratings, we attempted to find and organize professional projects, we practiced public speaking and parliamentary fencing with Robert's Rules of Order, we reviewed and discussed works on psychology, in fact we fearlessly weighed and tried every idea that suggested itself—and the stream of ideas seemed inexhaustible. This direct attack stage had its successes, even its miracles. One of the elements missing was intimacy. Once the group became an intimate circle the whole effort took on a depth of interest and we believe effectiveness not dreamed of before.

Convalescence for me from a serious operation forced the intimate circle pattern upon the group in 1939. Sunday morning breakfast became the meeting time. A new stage in the experiment was thus begun. Steady and regular monthly visits from Mr. Evans became heart-to-heart talks and the program took on the form of weekly forums. The principles to be studied and emphasized did not change. To a growing feeling of self sufficiency as a group our management engineer founder contributed a wealth of enthusiasm, optimism, and stories gleaned from his carrying the identical principles into his practice and into his spare time discussions of them in civic meetings, in talks before clubs, before church groups, colleges, high schools, in fact in talks to almost every kind of an audience.

Through this new form of meeting it soon dawned upon us that the effective technique for the practice of our principles—the real secret of personality development—was essentially the losing of one's self unselfishly in some activity and finding one's self in the leadership and team-work resulting from unselfish effort. We are urging the members of the group to do just this with respect to campus activities in which they are interested. Our next hope is to be still more objective about this very practice—invite freshmen into the group with the specific hope of inculcating this idea in them early. The rest of the group as upper-classmen then may guide, cheer, and console them into real personal development.

The real glow we get out of our efforts in these student associations comes from the individual miracles and successes that keep coming back to us from the various members and alumni. Three of our alumni graduated from here two years ago and formed a

Chicago group—that group has been taking up a methodical practice of maintaining positive attitudes in the office and shop. The desire of many after graduation to form little active groups in their new environments and the way they cling to the friendships made within the group seem to insure that the work started will go on even after graduation.

The experiment goes on—it has been so successful as to engage our interest and that of the students with ever increasing enthusiasm. It should be duplicated over and over everywhere—it may look like a 24-hour job for professors to not only give technical guidance but to devote themselves to the human development of their students in such an objective way as well—but it is so interesting and stimulating that the rewards greatly exceed the headaches that are attached to such a mode of approach. It gets at the personality problem as no less intimate approach will do. Like all such efforts time alone can mark up success with conspicuous instances of leadership—whether we reap such or not we believe we have accomplished much and we do not see why others could not be interested in carrying this kind of effort to the bulk of our student bodies through many small cells clustered around individual faculty members.

STATEMENT OF OBJECTIVES FOR ELECTRICAL ENGINEERING TRAINING*

By VICTOR P. HESSLER

Head, Department of Electrical Engineering
University of Kansas

All American industry is geared to the program of producing more and better goods with less materials and effort. Lack of materials and machines create serious problems which must be countered with substitute materials and new production methods. We, as engineering educators, are geared to the same program and are faced with as serious problems. The duties of many of our able teachers, now in industry, must be shouldered partly as additional loads by others and partly by untrained teachers. We must make every possible effort to prevent a drop in the quality of our product. The formulation and use of a statement of objectives is one tool we can use to aid in maintaining and, I hope, in improving our present quality of instruction. For several years I have been developing and using a statement of objectives to advantage in my own teaching and in planning the general training program of a department. The outline grew out of an attempt to define the professional status of an engineering student upon graduation.

What is a Graduate?

He is not an engineer. At least, so we have told him on many occasions. But "what a thing is not" is only half a definition and far from satisfactory in this case, I fear. What is his professional status upon graduation? He should be told early in his university training that the next four years are to be used to develop certain personal qualities, and acquire certain skills and knowledge all of which his prospective employer will expect him to bring to the first job. He will be expected to solve elementary problems with facility and precision and it is his duty to himself and to his employer to study the larger aspects of the project upon which he is assisting. In short he is not an engineer but he has skills and knowledge valuable to an engineering firm and he has the background upon which to build professional experience rapidly.

* Presented at the 49th Annual Meeting, S. P. E. E. (Electrical Engineering), University of Michigan, June 23–27, 1941.

If we are to train young men effectively for such positions we must give careful consideration to the selection of subject matter and adjust our methods to the results we hope to attain. An outline of personal qualities, skills and essential knowledge can be of real help in this connection.

UNIVERSITY TRAINING IN ELECTRICAL ENGINEERING

I. Personal qualities.
   - *A.* Personal standards of performance.
   - *B.* The habit of success.
   - *C.* Intellectual curiosity.
   - *D.* Perspective, balance, or judgment.
   - *E.* A social consciousness.
   - *F.* Courage.

II. Skills.
   - *A.* The scientific method: fact-finding and fact-facing.
   - *B.* Facility and precision in expression.
   - *C.* Facility and precision in the analytical process.
   - *D.* Facility and precision in electrical measurement.
   - *E.* Reasonable skill in making approximations—engineering judgment.
   - *F.* Ability to read effectively.
   - *G.* Ability to use the library.

III. Essential knowledge.
   - *A.* Cultural, social, and economic studies.
   - *B.* Fundamentals of electricity and magnetism. (Experimentally determined relations, defined relations and derived relations.)
      1. Coulombs law for charges (Exp.).
      2. Permittivity of free space (Def.).
      3. Electrostatic field intensity (Def.).
      4. Field intensity about a point charge (Der.).
      5. Electrostatic flux (Def.).
      6. Absolute electrostatic potential (Def.).
      7. Potential difference (Def.).
      8. Potential gradient (Def.).
      9. Flux from given charge (Der.).
      10. Capacitance (Def.).
      11. Dielectric constant (Def.).
      12. Absolute permittivity of a medium (Def.).
      13. Capacitance of a parallel plate condenser (Der.).
      14. Capacitance of a concentric cylinder condenser (Der.).

15. Capacitance of parallel wires (Der.).
16. Energy stored in a condenser (Der.).
17. Energy stored in a dielectric (Der.).
18. Force between parallel plates (Der.).
19. Electric current (Def.).
20. Ohms law (Exp.).
21. Resistance, resistivity (Def.).
22. Conductance, conductivity (Def.).
23. Kirchhoff's Laws (Der.).
24. Power dissipated in an electric circuit (Der.).
25. Resistance of a conductor (Exp.).
26. Variation of resistance with temperature (Exp.).
27. Faraday's law of induction (Exp.).
28. Lenz's law (Exp.).
29. Magnetic flux and flux density (Def.).
30. Flux cutting concept of induction (Der.).
31. Force on a conductor in a magnetic field (Der.).
32. Force between parallel current elements (Exp.).
33. Absolute permeability (Def.).
34. Force between moving charges (Der.).
35. Force between parallel conductors (Der.).
36. Flux density about a long straight wire (Der.).
37. Electromagnetic field intensity (Def.).
38. Field intensity about a current element (Der.).
39. Field intensity about a long straight wire (Der.).
40. Flux in terms of field intensity (Der.).
41. Magnetomotive force (Def.).
42. Magnetomotive force in a path linking a current carrying coil (Der.).
43. Flux density on the axis of a circular solenoid (Der.).
44. Flux density in a toroid (Der.).
45. Reluctance (Def.).
46. Relative permeability (Def.).
47. Inductance (Def.).
48. Inductance from circuit dimension (Der.).
49. Inductance of long straight wires (Der.).
50. Mutual inductance (Def.).
51. Coefficient of coupling (Def.).
52. Total inductance of coupled coils in series (Der.).
53. Energy stored in an inductance (Der.).
54. Energy stored in a magnetic field (Der.).
55. Force between magnetic pole faces (Der.).
56. Saturation curves (Exp.).

57. Flux produced in an iron cored circuit (Der.).
58. Iron losses (Der.).
59. Inductance of iron cored circuits (Der.).
60. Reactance (Def.).
61. Impedance (Def.).
62. Effective resistance (Def.).
63. Thermionic emission Der., Exp.).

C. Basic analytical and graphical methods.

1. Mesh current circuit analysis.
2. Dimensional analysis.
3. Curvilinear square flux mapping.
4. Vector representation of sine waves.
5. Complex algebra.
6. Symmetrical components.
7. Harmonic analysis.
8. Complex hyperbolic function analysis.
9. Leakage reactance.
10. Equivalent circuits.
11. Per unit analysis.

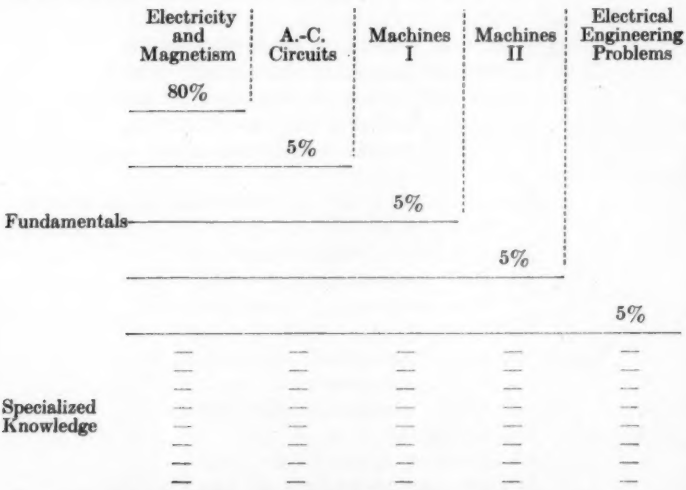
D. Topical outline of applied training.

1. Steady state solution of simple and complex d.-c. circuits.
2. Solution of elementary magnetic circuits.
3. Solution of elementary electrostatic circuits.
4. Steady state solution of complex a.-c. circuits.
5. Transient solution of R, L, and C circuits.
6. Solution of balanced and unbalanced 3-phase circuits.
7. Knowledge of operating characteristics, experimental determination of parameters and prediction of operating characteristics of:
   a. D.-C. generators and motors.
   b. Transformers.
   c. Alternators.
   d. Induction motors.
   e. Synchronous motors.
   f. Single phase induction motors.
   g. Converters.
   h. Mercury arc rectifiers.
8. Theory and applications of vacuum tubes.
9. Solution of circuits with distributed constants.
10. Analysis of nonsinusoidal waves.

USING THE OUTLINE

I have made the most effective use of the outline in connection with my senior problems course, a course in which the integrations of the essential fundamental training is the major objective. The slight familiarity of the fundamentals of electricity and magnetism is replaced with understanding by a study of the outline of experimentally determined, defined, and derived relations and by working many problems. The necessity for this review, however, will not be so great when our teaching of electricity and magnetism is made more efficient through the use of the M.K.S. system and generalized equations. Other problems serve to review and clarify the basic analytical and graphical methods. For example, the students are required to draw a vector diagram for a simple circuit and to give a rigorous statement concerning the location of each vector. This brings surprising results. The outline also suggests problems in fields which may not have been covered well in the previous courses. Thus the outline serves as a formula for a course to integrate and round-out the fundamental undergraduate training.

The outline also serves as a guide for reviewing and enhancing the fundamental concepts throughout the training period as illustrated below.



The courses listed are required in the sequence given. Each course includes a large number of special problems which depend upon the

application of fundamental principles for their solution. Most of the fundamentals are encountered in the first course and many may not be stressed again unless the instructors make a conscious effort to do so. For example, the study of commutation in Machines I provides a fine opportunity for enhancing the fundamental concept of inductance. The long lines are intended to portray the importance of reteaching and enhancing all of the fundamentals in each succeeding course.

Motivation is a serious problem even in engineering education where every student is preparing for a definite profession. However the students will really work on a problem for which they can see direct application. A logical and concrete outline of essential training placed in the student's hands helps him to check his progress toward professional status and thus creates a feeling of need for the subjects being studied. Such a process is far more satisfying and motivating than watching credits pile up in the registrar's office.

The personal qualities and many of the skills are not taught as such but are concomitants of the process of acquiring the essential knowledge. The personal qualities are habits largely and as such are acquired only through constant practice. When we require regular performance of a high quality we are developing at least two personal qualities which are more important than the subject matter involved. With the proper choice of problems we can develop some skill in making approximations and thus lay a foundation for engineering judgment. Since the development of personal qualities and skills is more a matter of how to teach than what we teach, it is desirable to have a statement of objectives at hand against which to check our methods.

I realize that no one statement of objectives can satisfy all conditions nor all personalities. However, I do feel the method has merit and hope that some may find it useful when modified to suit their personal needs.

ESSENTIALS OF COST CONTROL *

By JOHN A. WILLARD, Bigelow, Kent, Willard & Co., Boston

This discussion of the essentials of cost control has been prepared from the viewpoint of the needs of top management rather than purely from the point of view of an accountant. The industrial executive today expects his cost method to give him a reasonably comprehensive knowledge of the truth with regard to the costs of products made and sold with maximum simplicity in accounting operations.

Almost twenty years ago the writer, who had enjoyed an extensive experience in the manufacture of textiles, was assigned, together with an accountant, to devise a cost control method for a mill which spun its own yarns and produced a large volume of cotton hosiery and knit underwear. The accountant on this particular job continually pulled and hauled to maintain the most orthodox accounting techniques which were then in vogue. The writer believed that it was more important to develop adequate and accurate control information with regard to materials consumed, direct and indirect labor involved in manufacturing processes and factory expense rather than put the main emphasis on accounting procedures which would insure a strict adherence to the technique of accounting as it was then practiced.

Surprisingly enough, the net result of this pulling and hauling, which produced numerous compromises on both sides, was unusually successful. Definite control was established with maximum simplicity in accounting operations with, however, no neglect of fundamental accounting and auditing principles.

It is significant, however, that a small point of psychology came near wrecking the whole cost system. The old maid bookkeeper who kept the Cash Receipts book in the Treasurer's Office didn't like it because she was asked to operate a Cash Receipts book with a standard length page which was two inches shorter than what she had used for years. It was discovered that she had more influence with the Treasurer than either the engineer or the accountant or both of them combined. It is, therefore, perhaps quite important that we recognize at the outset that one of the essentials of cost control involves giving due regard to the sensibilities of those trusted employees who must operate the cost control.

* All figures quoted are illustrative only.

Some time after the experience just related, another Company decided to have a cost control plan devised and installed. The plant was in a line of business which can be classed as the needle trades, and the operations covered cutting, seaming, finishing and inspection, a type of plant extremely well-adapted to the application of standard costs. When the devising was about three-quarters completed and some of the control routines had already started to be installed, the President of the Company, who was an elderly man, again made inquiry as to the number of clerks that would be required to operate the method. Inasmuch as there were about five hundred employees in the plant, he was told that it should require approximately two additional clerks. He had been told this figure earlier but on account of his advanced age had not paid much attention to the information. Now, after being again informed that two additional clerks would be required he exercised the prerogative of an executive by stating that no additional clerks would be provided and that if the method could not be operated with the clerks already in the factory and office they would get along without the method.

This statement not only caused a good deal of consternation on the part of those responsible for the installation, but it made them really go to work. The net result was that a new and improved plan of working up the "standard labor" figure each week was developed which has been used with considerable success on many subsequent installations.

The new technique permitted the method to be continued in the plant without additional clerical employees, partly because there was considerably less work and also partly because not all his office employees were fully engaged at the time of the ultimatum.

But certainly on this job both the engineer and the accountant found out that simplicity of design could have benefits both for the employer and themselves.

In the past twenty-five years the work of the theoretical accountant has been ably supplemented by certain concepts of management engineers. It seems to be reasonably well recognized that G. Charter Harrison was the earliest to write about standard costs, even though he may not be the sole originator. His early concepts of standard costs were, in fact, based on fundamental work carried out when he was associated with the late Charles E. Knoeppel. Mr. Knoeppel, with whom I deem it a pleasure to have been associated for about four years, lacked the accounting experience to enable him to devise or operate an accounting system, but he could ably develop new and original concepts by which to apply standards of plant operation to costing procedures. I personally know that Mr. Knoeppel has been responsible for a number of valuable contribu-

tions to the technique of present-day cost control—particularly the use of variance accounts.

The first essential in developing a cost plan for any business is careful examination of the nature and the diversity of the manufacturing processes. One must determine what type of cost collection method will permit the most simple but accurate cost control. It is believed correct to state that more cost systems fail because the bases that were selected for figuring costs were wrong bases, than for any other reason. Improper base selection leads to distorted cost information and the adoption of unsound management policies as a result of the misinformation. For instance, in a hosiery mill an inaccurate basis of distribution of overhead expense to a range of styles may result in over-pricing low-end merchandise and under-pricing quality goods. This policy kills volume and stops profits.

As the management engineer examines a business to determine what he would advise, the problem quickly takes on an old and familiar pattern. He knows that before he has finished with the job he must do four things:

1. Determine what facts he needs to obtain.
2. Devise and operate a plan to gather the desired information.
3. Analyze the data gathered to determine their significance.
4. Present the results of analysis so it will be unmistakably understood by the executive for whom the facts are gathered.

The above is not unique. It is a reasonably adequate formula for approaching almost any problem that needs to be solved for top management.

The cost factors to which attention must be directed when examining a manufacturing plant depend largely on the type of business and the kind of process.

In contract shops where two jobs are seldom the same, it is often necessary to have a complete record of process costs not only for control purposes but also for job-order costs. These process costs are needed for two reasons: first, to determine whether various fundamental processes, such as plating, are conducted efficiently; and, second, to aid in the pricing of similar jobs in the future.

Similarly it may be essential to have a knowledge of operation costs; for instance, how much it costs to bore and grind cylinders or to drill holes in each of several size ranges.

In repetitive manufacturing it is often possible to use product

costs in conjunction with special-order costs for the small portion of production which departs from the normal.

Further, for the sake of simplicity it is often possible to classify a large line of products by various "class" groups so that class costs may be obtained. As a matter of fact, this classification technique fits especially well into process standardization and wage incentive plans where simplification is necessary to prevent the method from breaking down of its own weight.

An example of the need of classification is found in the manufacture of lighting fixtures in which many small castings for arms, canopies and bases must be classified by diameter, length and contour. Similarly, numerous metal stamping and spinning operations must be classified in groups, and also rods and tubing. The wide diversity of products is thus shrunk into sufficiently few classifications to permit their practical handling and the application of fundamental operational costs.

As a rule, the classifications which are sensible for wage standardization can be adopted directly for cost work. The principal exceptions will arise from a difference in material which does not happen to affect handling cost but does happen to affect the control of accounting for material.

Along with the "actual cost" methods just cited above is also involved the problem of establishing a close control of material, labor and departmental or process expense for all operations.

Although we have so far not mentioned the methods especially applicable to standard costing procedure, the product and class costs just described form an integral part of the departmental operation of standard costs.

After obtaining actual costs either by job-order or process, we still have very little idea as to what the cost *should be* for a process or an operation or a product unless we compare the actual with other figures or with standard costs. Most people who operate actual cost plans make these comparisons statistically, month by month and year by year. In many cases, however, they do not compare these costs with what a close study would indicate the costs ought to be. Over twenty years ago, Mr. G. Charter Harrison wrote about standard cost routines which have since been called "ideal standard costs." This system of Ideal standard costs as pioneered and refined by Harrison and others has received very broad application. Its nearest competitor is a system of so-called "basic standard costs" developed by Eric Camman. Both types of cost control system tell

1. The basic facts as to process and operation costs, and
2. The current trend.

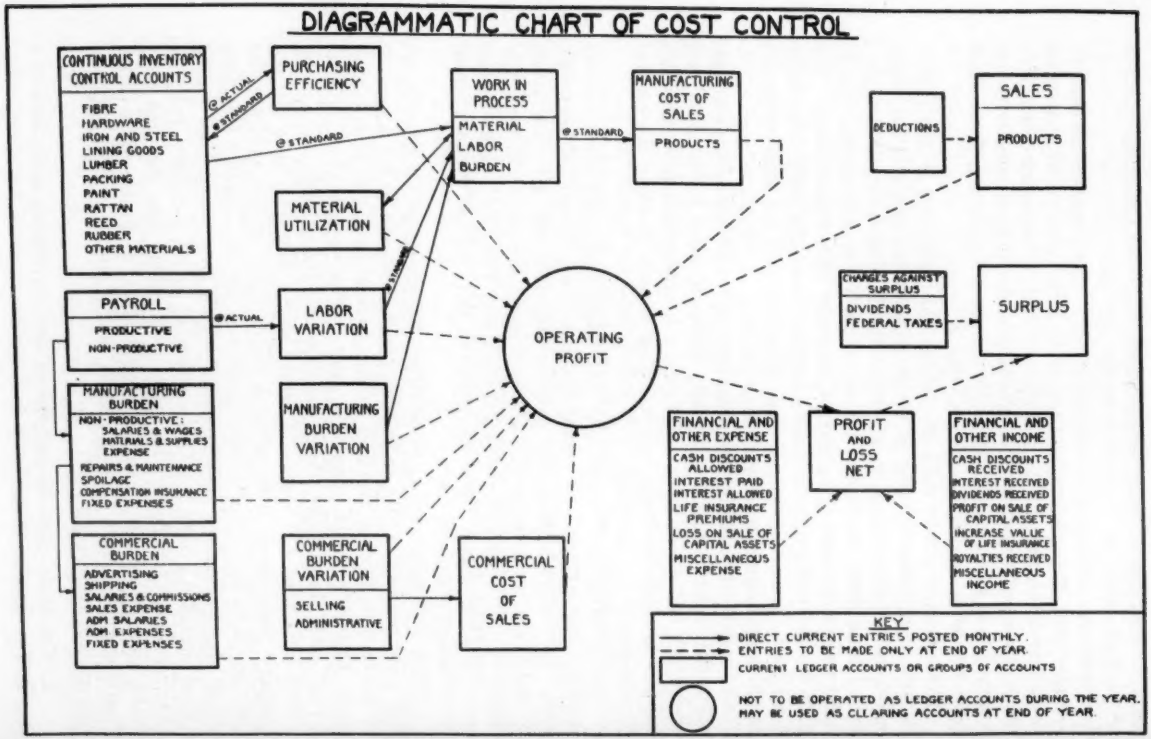


FIG. 1. Diagrammatic chart of cost control.

This figure pictures the flow of accounting values through an Ideal system of standard costs. The column of accounts at the extreme left collects actual costs of Raw Material, Labor and Burden. Actuals are then adjusted to Standards by adding or subtracting the necessary amount at the Variation Accounts in the column just at the right of the Actual Accounts. Then continuing to the right, at the top of the figure, we see that standard costs are used to compute the cost of Work-in-Process and Manufacturing Cost of Sales. This Cost of Sales is then charged into Operating Profit. The Gain or Loss after the Variation Accounts is also transferred to Operating Profit. These various costs are subtracted from Sales which was also transferred to Operating Profit, and the difference or Net Operating Profit to the Profit and Loss Account. From here the accounting proceeds in the usual manner, with entries for Other Financial Expense, Income, Dividends, Taxes and Surplus.

The significant thing to note is that the Variation Accounts are placed between Actual Accounts at the extreme left and Work-in-Process in the center. Under the Ideal plan the values for Work-in-Process and Finished Goods Accounts are priced at "standard" throughout, and so, if the report of quantities used is substantially accurate, the book and physical inventories should check fairly closely, forming a positive control of values.

Returning to a more direct comparison of the Ideal and Basic Standard Cost plans, the Ideal is simpler than the Basic Cost System. The Ideal sets up and uses standards to represent actual operation as nearly as is possible.

The inventory values for raw materials, work-in-process and finished goods are charged at standard values until the end of the year, at which time they are usually adjusted by reserve accounts to approximate closely the actual cost figures existing at the end of the year.

During the year the variation accounts are used to show the differences between standards and actuals for material, labor and overhead in the several classifications. These variation accounts are indicators of the effectiveness of operation and the effect of plant and sales volume.

The Basic method charges materials and labor to manufacturing cost at actual cost and sets up variation accounts which show the difference between standard and actual costs for material, labor and overhead. Then the variation accounts are closed out monthly to Cost of Sales in proportion to sales volumes. Standards are not changed even in the face of marked changes of material prices or wage rates. The variation accounts show trends and improvements.

Both plans provide as much subdivision of expense for proration into cost centers as is desirable. They also provide for ade-

MAY BE USED AS CLEARING ACCOUNTS AT END OF YEAR.

FIG. 1. Diagrammatic chart of cost control.

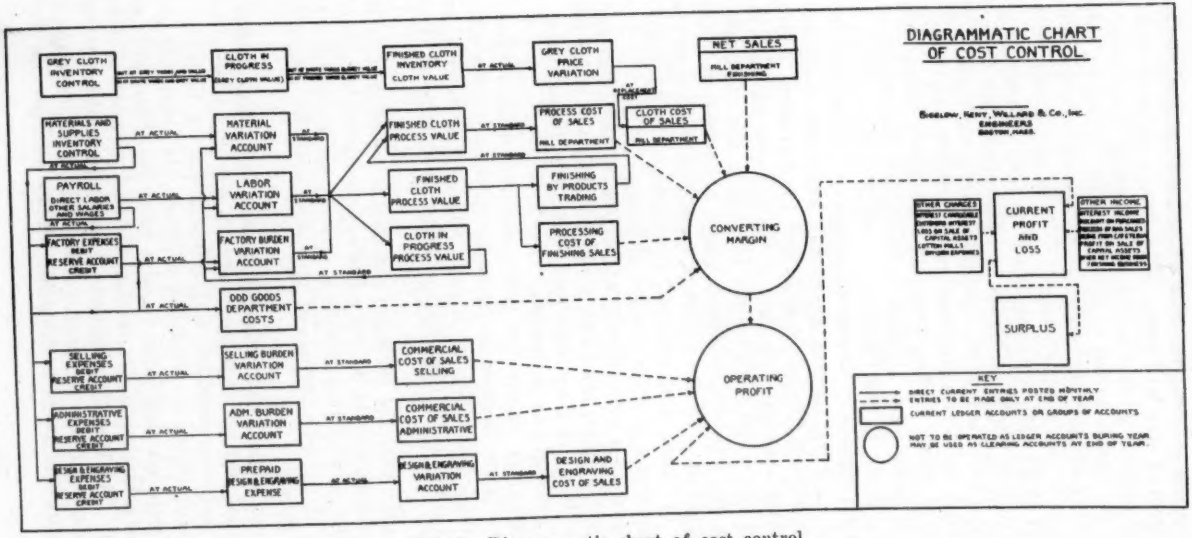

DIAGRAMMATIC CHART OF COST CONTROL
Bigelow, Kent, Willard & Co., Inc. ENGINEERS BOSTON, MASS.
GREY CLOTH INVENTORY CONTROL
CLOTH IN PROGRESS
FINISHED CLOTH INVENTORY
CLOTH VALUE
GREY CLOTH PRICE VARIATION
NET SALES
MILL DEPARTMENT FINISHING
MATERIALS AND SUPPLIES INVENTORY CONTROL
MATERIAL VARIATION ACCOUNT
FINISHED CLOTH PROCESS VALUE
PROCESS COST OF SALES
MILL DEPARTMENT
CLOTH COST OF SALES
MILL DEPARTMENT
PAYROLL
DIRECT LABOR OTHER SALARIES AND WAGES
LABOR VARIATION ACCOUNT
FINISHED CLOTH PROCESS VALUE
FINISHING BY PRODUCTS TRADING
FACTORY EXPENSES DEBIT
RESERVE ACCOUNT CREDIT
FACTORY BURDEN VARIATION ACCOUNT
CLOTH IN PROGRESS PROCESS VALUE
PROCESSING COST OF FINISHING SALES
CONVERTING MARGIN
ODD GOODS DEPARTMENT COSTS
SELLING EXPENSES DEBIT
RESERVE ACCOUNT CREDIT
SELLING BURDEN VARIATION ACCOUNT
COMMERCIAL COST OF SALES SELLING
ADMINISTRATIVE EXPENSES DEBIT
RESERVE ACCOUNT CREDIT
ADM. BURDEN VARIATION ACCOUNT
COMMERCIAL COST OF SALES ADMINISTRATIVE
OPERATING PROFIT
DESIGN & ENGRAVING EXPENSES DEBIT
RESERVE ACCOUNT CREDIT
PREPAID DESIGN & ENGRAVING EXPENSE
DESIGN & ENGRAVING VARIATION ACCOUNT
DESIGN AND ENGRAVING COST OF SALES
OTHER CHARGES
CURRENT PROFIT AND LOSS
OTHER INCOME
SURPLUS
KEY
DIRECT CURRENT ENTRIES POSTED MONTHLY
ENTRIES TO BE MADE ONLY AT END OF YEAR
CURRENT LEDGER ACCOUNTS OR GROUPS OF ACCOUNTS
NOT TO BE OPERATED AS LEDGER ACCOUNTS DURING YEAR MAY BE USED AS CLEARING ACCOUNTS AT END OF YEAR.

FIG. 2. Diagrammatic chart of cost control.

quate comparisons of overhead expense per hour of operation or per unit of production.

Aside from the personal preference of the accountant who makes the installation, the decision as to which general type or method to adopt will depend on the character of the business. It is never wise to adopt any cost method or cost philosophy unless it fits an individual plant perfectly. Patented systems in costing procedure are more dangerous than almost anywhere else among the tools of top management.

For instance, if the principal raw materials used in a business fluctuate widely in value as do rubber, leather, textiles and copper, there will be definite advantages in carrying inventories at "actuals" rather than "standards," and it is likely to be advantageous to adjust the inventory values to market values monthly by the use of inventory adjustment accounts. Under conditions of this sort, the Basic method is distinctly preferred.

However, when material values remain fairly stable the Ideal method can be applied to cost control with less clerical effort. The fluctuations, even under emergency conditions, will then appear in the variation accounts and adjustment of inventory values can well await the end of the year even though the inventory accounts may be temporarily distorted.

In some industries, such as the converting of cotton gray goods or in the manufacture of articles where copper is the principal raw material, the selling prices are quoted at a definite conversion cost over and above the base price of the cotton goods or the copper on that day's market. In such cases, the Material Price Variation Account should go between the Finished Goods Account and the Material Cost of Sales, as is shown on this cost chart. Fig. 2.

Avoiding distortion of cost facts is the fundamental principle which it is essential to watch throughout development and application of any cost control plan.

As stated previously, the analysis of figures and the form of reports presented to management are paramount among the more important phases of cost control.

Figure 3 shows a form of Profit and Loss statement that is especially valuable for indicating the overall results of the Company. However, the overall results may conceal a tremendous amount of pertinent cost control facts under the weighted average of operations which the net Profit and Loss truly represents. Therefore this skeletonized Profit and Loss statement should be supplemented by a report to indicate at least the gross profit margin on the various lines of goods. A study of gross profit margins is highly essential and as a matter of fact a study of net profit margins per line of product as well.

MONTHLY PROFIT AND LOSS STATEMENT

	August	September	October
Gross Sales:			
Sales of Merchandise	00 00		
Sales of Waste	00 00		
Total Sales	00 00		
Less: Commissions	00 00		
Returns and Allowances	00 00		
Total Deductions	00 00		
Net Sales	00 00		
Cost of Sales:			
Standard Manufacturing Cost of Sales:			
a—Material	00 00		
b—Labor	00 00		
c—Burden	00 00		
Total Standard Manufacturing Cost of Sales	00 00		
Gross Manufacturing Profit	00 00		
Standard Commercial Cost of Sales	00 00		
Standard Operating Profit	00 00		
Adjustments to Actual Profit or Loss * due to:			
1—Material Variation	00 00		
2—Labor Variation	00 00		
3—Burden Variation (Mill)	00 00		
3—Burden Variation (Commercial)	00 00		
Total Adjustments	00 00		
Actual Operating Profit	00 00		
Other Income:			
Purchase Discounts	00 00		
Interest Received	00 00		
Other Income	00 00		
Total Operating Profit and Other Income	00 00		
Other Expense:			
Sales Discounts	00 00		
Interest Paid	00 00		
Loss on Sale of Capital Assets	00 00		
Other Losses	00 00		
Total Other Expense	00 00		
Net Profit or Loss *	00 00		

* Red.

FIG. 3. Monthly profit and loss statement.

This figure shows three years of operation for a company in which the upward trend of losses on some of the products is notable, yet the overall operating results are still quite satisfactory. The point is that without a thorough knowledge of the gross profit margin of the cost to sell by lines of products, and of the resulting profit pattern, sound operational policies cannot be established.

In the preceding we have mentioned the words "profit pattern." This is the characteristic curve of volume and profitability for any one product within a line. The profit result for the company as a whole is, of course, the summation of the volume and profit characteristics of each of the lines of products. Valuable use can be made of this profit pattern by balancing efforts to secure large-volume, low-margin business against better profit earners in higher quality lines. It should be recognized that a uniform percentage of net profit based only on the sales dollar is quite impossible and so it is highly essential to balance the profit pattern for the line as a whole to assure both adequate volume and a fair net return on the total business.

In addition to costing sales expense for allocation to lines of product as just touched upon, it is likewise important to know the direct field cost of selling for each salesman. It is quite feasible to keep a running record of "cost to sell by salesmen" currently and to-date without tying the figures into the books. Thus each man's performance can be closely checked and, whenever possible, he can be rewarded accordingly.

Profit studies of salesmen of the type just discussed when extended over a considerable period often indicate that a salesman may show a loss for his territory. Although every effort should be made to determine the cause of the loss and then to improve the operation or replace the salesman, sales activity in this loss-territory should not be too hastily withdrawn. Withdrawal should not generally be considered until the operating loss exceeds the sum of the manufacturing and commercial overhead absorbed.

A great deal has been written on the validity of Profit and Loss Statements by G. Charter Harrison and many other contributors to the bulletins of the National Association of Cost Accountants. Most Profit and Loss Statements are inaccurate. In fact, practically all Profit and Loss Statements prepared in the traditional manner are incorrect. The only exceptions occur in those rare periods when sales happen to equal production. Without going into a long dissertation on the causes of this inaccuracy, it may be said that production at a high rate creates inventory values having low overhead per unit and, on the contrary, production at a low rate creates inventory values having high overhead per unit. Of

Product Profitability 1940, 1939 and 1938

	Net Sales		Material		Labor		Burden		Total Manufacturing Cost of Sales		Gross Profit		Administrative		Selling		Advertising		Total Commercial Cost of Sales		Operating Profit	
	Amount	Rel. to Sales $	Amount	Rel. to Sales $	Amount	Rel. to Sales $	Amount	Rel. to Sales $	Amount	Rel. to Sales $	Amount	Rel. to Sales $	Amount	Rel. to Sales $	Amount	Rel. to Sales $	Amount	Rel. to Sales $	Amount	Rel. to Sales $	Amount	Rel. to Sales $
1940																						
Product A	$1,315,700	1.000	$252,800	.192	$274,900	.209	$183,600	.140	$ 711,300	.541	$604,400	.459	$ 77,000	.059	$206,800	.157	$46,200	.035	$330,000	.251	$274,400	.208
B	33,300	1.000	7,900	.238	8,900	.267	6,000	.180	22,800	.685	10,500	.315	2,500	.075	8,300	.249	600	.018	11,400	.342	900*	.027*
C	7,200	1.000	1,900	.264	2,100	.292	1,400	.194	5,400	.750	1,800	.250	700	.096	400	.056	400	.056	1,500	.208	300	.042
D	59,700	1.000	64,800	1.085	—	—	—	—	64,800	1.085	5,100*	.085*	9,400	.158	2,800	.047	900	.015	13,100	.220	18,200*	.305*
E	12,300	1.000	7,500	.610	—	—	—	—	7,500	.610	4,800	.390	1,100	.089	700	.057	—	—	1,800	.146	3,000	.244
F	4,400	1.000	3,200	.727	—	—	—	—	3,200	.727	1,200	.273	500	.114	300	.068	—	—	800	.182	400	.091
G	89,000	1.000	17,100	.192	19,400	.218	13,000	.146	49,500	.556	39,500	.444	5,300	.060	26,700	.300	4,700	.052	36,700	.412	2,800	.032
H	51,200	1.000	5,500	.107	8,200	.160	5,500	.108	19,200	.375	32,000	.625	2,000	.039	5,400	.106	—	—	7,400	.145	24,600	.480
I	145,800	1.000	137,800	.945	—	—	—	—	137,800	.945	8,000	.055	19,900	.136	9,200	.063	1,100	.008	30,200	.207	22,200*	.152*
J	74,100	1.000	65,300	.881	—	—	—	—	65,300	.881	8,800	.119	9,500	.128	100	.002	600	.008	10,200	.138	1,400*	.019*
K	8,000	1.000	7,400	.925	—	—	—	—	7,400	.925	600	.075	1,000	.125	1,000	.125	—	.025	2,200	.275	1,600*	.200*
L	3,600	1.000	2,700	.750	—	—	—	—	2,700	.750	900	.250	400	.111	300	.083	—	—	700	.194	200	.056
M	5,900	1.000	300	.051	—	—	—	—	300	.051	5,600	.949	—	—	2,500	.424	—	—	2,500	.424	3,100	.525
Total	1,810,200	1.000	574,200	.317	313,500	.173	209,500	.116	1,097,200	.606	713,000	.394	129,300	.072	264,500	.146	54,700	.030	448,500	.248	264,500	.146
1939																						
Product A	1,115,900	1.000	212,400	.190	247,800	.222	134,800	.121	595,000	.533	520,900	.467	63,400	.057	144,200	.129	47,600	.043	255,200	.229	265,700	.238
B	31,700	1.000	8,000	.252	10,600	.335	5,700	.180	24,300	.767	7,400	.233	2,500	.079	5,400	.170	500	.016	8,400	.265	1,000*	.032*
C	23,000	1.000	4,300	.187	6,300	.274	3,400	.148	14,000	.609	9,000	.391	1,400	.061	700	.030	500	.022	2,600	.113	6,400	.278
D	70,500	1.000	63,300	.898	—	—	—	—	63,300	.898	7,200	.102	6,600	.094	2,900	.041	900	.013	10,400	.148	3,200*	.046*
E	18,000	1.000	10,600	.589	—	—	—	—	10,600	.589	7,400	.411	1,100	.061	400	.022	—	—	1,500	.083	5,900	.328
F	10,300	1.000	5,700	.553	—	—	—	—	5,700	.553	4,600	.447	600	.058	900	.087	—	—	1,500	.146	3,100	.301
G	97,600	1.000	17,100	.175	27,300	.280	14,700	.151	59,100	.606	38,500	.394	6,100	.062	23,600	.242	4,800	.049	34,500	.353	4,000	.041
H	52,600	1.000	12,100	.230	3,900	.074	2,100	.040	18,100	.344	34,500	.656	200	.004	3,600	.068	—	—	3,800	.072	30,700	.584
I	304,600	1.000	270,400	.888	—	—	—	—	270,400	.888	34,200	.112	28,100	.092	27,300	.090	1,200	.004	56,600	.186	22,400*	.074*
J	13,900	1.000	13,900	1.000	—	—	—	—	13,900	1.000	—	—	1,400	.101	500	.036	500	.036	2,400	.173	2,400*	.173*
K	15,500	1.000	8,600	.555	—	—	—	—	8,600	.555	6,900	.445	900	.058	400	.026	200	.013	1,500	.097	5,400	.348
L	3,500	1.000	2,700	.771	—	—	—	—	2,700	.771	800	.229	300	.086	100	.029	—	—	400	.115	400	.114
M	4,700	1.000	2,300	.489	—	—	—	—	2,300	.489	2,400	.511	—	—	—	—	—	—	—	—	2,400	.511
Total	1,761,800	1.000	631,400	.358	295,900	.168	160,700	.092	1,088,000	.618	673,800	.382	112,600	.064	210,000	.119	56,200	.032	378,800	.215	295,000	.167

									2,300	.489	2,400	.511	—	—	—	—	—	—	—	—	2,400	.511
Total	1,761,800	1.000	631,400	.358	295,900	.168	160,700	.092	1,088,000	.618	673,800	.382	113,600	.064	210,000	.119	56,200	.032	378,800	.215	295,000	.167

Product Profitability 1940, 1939 and 1938—*Continued*

	Net Sales		Material		Labor		Burden		Total Manufacturing Cost of Sales		Gross Profit		Administrative		Selling		Advertising		Total Commercial Cost of Sales		Operating Profit	
	Amount	Rel. to Sales $	Amount	Rel. to Sales $	Amount	Rel. to Sales $	Amount	Rel. to Sales $	Amount	Rel. to Sales $	Amount	Rel. to Sales $	Amount	Rel. to Sales $	Amount	Rel. to Sales $	Amount	Rel. to Sales $	Amount	Rel. to Sales $	Amount	Rel. to Sales $
1938																						
Product A	956,400	1.000	193,900	.203	215,500	.225	119,800	.125	529,200	.553	427,200	.446	60,000	.063	62,400	.065	30,000	.031	152,400	.159	274,800	.287
B	51,100	1.000	14,300	.280	17,800	.348	9,800	.192	41,900	.820	9,200	.180	4,700	.092	3,000	.059	400	.008	8,100	.159	1,100	.021
C	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
D	8,900	1.000	7,400	.831	—	—	—	—	7,400	.831	1,500	.169	800	.090	1,400	.157	800	.090	3,000	.337	1,500*	.168*
E	18,200	1.000	12,000	.659	—	—	—	—	12,000	.659	6,200	.341	1,300	.072	400	.022	—	—	1,700	.094	4,500	.247
F	7,900	1.000	3,400	.430	—	—	—	—	3,400	.430	4,500	.570	400	.051	100	.012	—	—	500	.063	4,000	.507
G	60,900	1.000	15,800	.259	17,400	.286	9,700	.159	42,900	.704	18,000	.296	4,800	.079	4,300	.071	2,900	.047	12,000	.197	6,000	.099
H	42,400	1.000	10,300	.243	7,300	.172	4,700	.111	22,300	.526	20,100	.474	2,500	.059	2,100	.049	—	—	4,600	.108	15,500	.366
I	263,000	1.000	240,200	.913	—	—	—	—	240,200	.913	22,800	.087	27,400	.104	4,300	.016	800	.004	32,500	.124	9,700*	.037*
J	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
K	16,200	1.000	13,000	.802	—	—	—	—	13,000	.802	3,200	.198	1,400	.086	500	.031	400	.025	2,300	.142	900	.056
L	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
M	6,000	1.000	3,800	.633	—	—	—	—	3,800	.633	2,200	.367	—	—	100	.017	—	—	100	.017	2,100	.350
Total	$1,431,000	1.000	$514,100	.359	$258,000	.180	$144,000	.101	$ 916,100	.640	514,900	.360	$103,300	.072	$ 78,600	.055	$35,300	.025	$217,200	.152	$297,700	.208

* Figures in red.

Costs and profits by line of product are much more valuable than total costs and profits.

Fig. 4. Product profitability, 1940, 1939, 1938.

course, the overhead per unit should correspond exactly with the rate of sales.

Many experiments have been made in presenting different types of Profit and Loss Statements in the attempt to correct this aberration due to overhead. It is technically possible to split standard sales costs into the true fixed and true variable portions, and to show the standard fixed cost as well as the standard variable portion of sales cost. Then, if the total of fixed costs is deducted from the net income and the variable portion of costs, proportionate to sales volume, is taken out, a true profit and loss statement is obtained. However, in getting the true profit we obscure the true gross profit per line of product, and on this form of statement the net P and L figure is about the only thing on the sheet that really rings a bell in the consciousness of the average executive, except that the "Marginal Balance" is shown. Few executives as yet believe the "Marginal Balance" theory is really an actual fact.

Accordingly, it seems preferable to get a true picture in a different way. The Profit and Loss Statement is prepared in the normal manner, showing the gross profit at standard and all the variations for material, labor and overhead from actual and, finally, a net profit figure, which is inaccurate. It is then quite easy to correct the fictitious book profit by calculating the error. The error is computed by multiplying the increase or decrease in inventory for the month by the per cent of fixed costs in the total standard manufacturing costs. On standard or Ideal cost plans a constant per cent of fixed expense for the year often can be used for the inventory multiplier. On non-standard and Basic cost plans, the per cent of fixed expense applying to each month is used to correct the cost statement.

As stated previously, high production for any month or period lowers overhead costs per unit and this lowers inventory values per unit. Profits are correspondingly inflated for that period. The profit figure can be corrected by multiplying the dollar increase in inventory by the per cent of fixed costs in inventory, then the result is deducted from the book profit. If the inventory has decreased the result of the multiplication is added to the book profit.

It is recognized that this type of correction is scarcely needed in many businesses because the rate of production and rate of sales are sufficiently stabilized. Nevertheless our experience has been that in certain cases this normal type of Profit and Loss Statement, when corrected, provides a better control than the technically more accurate method which obscures the margin of gross profit by deducting all fixed costs first. Marginal Balance can be separately determined.

Checks and tests of the types we have indicated are part of the essentials of cost control. However, a discussion of this kind would be incomplete without a reference to the comparative ease of drawing up a "break-even" chart for the business to show the projected operations for a year, or for a given month, against which actual operation may be compared when and if the Profit and Loss Statement is corrected by the inventory adjustment.

You are all familiar with the construction of the break-even chart, which appears often in technical papers on cost control and yet is too seldom used in checking actual month-by-month operation.

There are two reasons why this valuable tool is so seldom used effectively:

First, the operating statement has not been corrected for variation due to inventory fixed expense as previously indicated, and

Second, far too often the assumption is made that selling prices have remained constant.

Much tinkering has been done with the line for cost on break-even charts, but very little has been done with the line for sales-income.

For instance, just recently a manufacturer consistently resisted all efforts to give him any idea of the results from adoption of various price policies. A meeting would be held, and the pricing situation would be discussed and that was all. For although this man had a highly refined control over everything but the fluctuations in his selling prices, he seemed not to want to know the results of changes in pricing policy.

This uncertainty continued for about four years and then, in the early part of the fourth year, a genuine price war started, at which time permission was finally obtained to work up a monthly price index. No true price variation account could be operated in this manufacturer's business because there were no standard prices or discount lists from which to work. However, an index was finally made by combining the price per pound for five different lines of product with the average weight per piece per line of product, which was also an influencing factor on the price per pound. Figures for the index were obtained from records going back to a point before the price war started and they showed plainly and clearly that the opening gun of the price war knocked off about seventeen per cent of the dollar sales. The price war is still in progress and the price index shows that this manufacturer is now operating on an income level per pound which averages almost twenty-five per cent below what he previously considered a none-too-liberal normal.

To allow for this decrease in income, in making use of the chart, the cost line on the break-even chart is arbitrarily raised by an amount in dollars equal to the lowered prices. This adjustment, with much-reduced clerical expense, permits him to foresee results which in his circumstances could not be foretold in any other way.

Our brief consideration of reports for executives would not be complete without some attention to departmental reports. These are designed to show losses or gains by comparison with standards for the expense center of each department.

It is customarily considered that budgets may be separate and distinct from cost control, on the same principle that a person can have measles without at the same time having mumps. However, if cost standards are properly prepared and correctly broken down into their fixed and variable elements, the cost control can embody most of the good things inherent in budgetary procedure. Although it is possible to get cost control without preparing either a working capital budget or a cash budget, costs cannot be controlled without knowing the standard or budgetary figures, both fixed and variable, for departmental operation.

Of course, a complete budget can act as a *negative* control to prevent doing things that had not been planned, but it is more important to use the budget to exercise *positive* control in forecasting and planning income, and for pro-rata planning of outgo and pre-planning of profits. The budget fixes responsibilities—particularly responsibilities of departmental operating heads who, in the last analysis, control the sources of operating expense.

An unknown writer has said, "Forecasts are but picture frames placed about a canvas of business facts too vast to be exactly measured and too fugitive to be entirely captured." It is often true that, in preparing the budget schedule, the budget committee will meet difficulties in establishing reasonably accurate forecasts for sales income and for the types of products that are going to be bought by the customers, but departmental expenses permit of a much closer degree of estimation and proportioning of fixed and variable expense.

When making the departmental study it is desirable to examine carefully each item of expense to find out what causes the up-and-down surges so characteristic of many expense items. By applying sufficient analysis, normal departmental charges can be more nearly regularized, after which allowance can be made separately for abnormal items during the procedure of establishing standards.

In addition to making a detailed study of departmental expenses for a year or two, it is well to chart these expenses to see more clearly the cause of the expense variations which accompany changes in departmental volume. After charting the expenses, character-

istic expense curves can be drawn, from which the equation of variable expense may be obtained, and also the fixed departmental costs.

Any one of the following methods may be used to determine the characteristic expense curve:

1. Method of least squares.
2. First degree equation.
3. Second degree equation (rarely necessary).
4. Draw a line by inspection. (This is sufficiently reliable to use when in a hurry.)

DECORATING

Decorating and Decorating Lehrs

	Standard	Actual	Gain Loss	Accl. Gain-Loss
Indirect Labor	1341.32	1534.84	*193.52	*809.56
Controllable Supplies	460.06	232.04	228.02	1025.74
Fuel	420.37	312.72	107.65	341.25
Water	—	—		
Compensation Ins.	21.93	16.23	5.70	11.56
Social Security	128.81	110.01	18.80	12.57
Total Burden	2372.49	2205.84	166.65	581.56
Direct Labor	1900.20	1615.24	284.96	1112.06
Direct Material	1186.20	661.10	525.10	1941.66
Total Expense	5458.89	4482.18	976.71	3635.28

* Red.

FIG. 5. Decorating and decorating lehrs.

This shows the expense estimate and operating statement for one department in a glass manufacturer's plant.

Because of interlocking variables, these departmental expense statements must be built up by departmental totals and the estimating basis for variable expense (pounds or dozens or yards) clearly determined. Similarly, the total variable expense for the plant must be a summation. Experience has proved that it is inaccurate to analyze totals only.

Figure 6 shows a report of total plant expense for the same plant. It is the type of report which arises as a result of comparing standards with actuals. It should be borne in mind that these standards for the month are of a flexible budgetary nature and are not the ones used for standard unit costs. They coincide with the ones used for standard costs only at the so-called normal volume at which the standard costs are calculated. The standards on this chart con-

ANALYSIS OF MANUFACTURING EXPENSES

	Standard	Actual	Gain Loss	Accl. Gain-Loss
Superintendence	544.40	544.40	—	—
Indirect Labor	6962.50	7586.61	*624.11	*2222.63
Controllable Sup-Exp.	1683.50	1751.92	* 68.42	296.79
Fuel Oil	3963.74	4488.64	*524.90	*1780.16
Pots	780.00	528.00	252.00	* 69.66
Water	—	—		
Compensation Insurance	427.18	376.62	50.56	134.65
Social Security	993.06	1092.51	* 99.45	* 325.54
Dep-Ins.-Taxes	269.42	269.42	—	—
Broken Ware	200.00	200.00	—	—
Moulds	2040.59	1249.38	791.21	*1343.39
Unabsorbed Freight	54.65	69.15	* 14.50	32.96
Lehr Royalty	130.00	130.00	—	—
Other Royalty	62.69	62.69	—	—
Total Burden	18111.73	18349.34	*237.61	*5276.98
Direct Labor	19564.38	19050.10	514.28	1836.40
Direct Material	12183.32	11719.96	463.36	1494.42
Total Expenses	49859.43	49119.40	740.03	*1946.16

* Red.

FIG. 6. Analysis of manufacturing expenses.

form to those which would be obtained from the use of a flexible budget. Each item of standard expense contains that portion of fixed which is truly fixed, and the variable amount has been calculated in proportion to the actual departmental volume; so that the figure for standard costs presented in these reports is the amount that should have been spent for the volume produced, provided the standards had been adhered to. This type of report can be of tremendous value in controlling operations, in seeking out unusually fine performance for an incentive reward to supervisors, and in stopping losses before they become too firmly ingrained in the structure of the organization.

In conclusion, only some highlights of the essentials of cost control have been touched upon in this brief paper. As you well know, it would require a volume to present anything like an adequate coverage of this important subject. The attempt has been made to present only the more important points essential to cost control as seen from the viewpoint of one working more with top management than strictly in the accounting field.

The first eighteen centuries of effort in the world brought forth gunpowder, the printing press and, finally, mechanical power. The last half century has produced a steady advance along lines that

have had a deep-seated effect on the social phases of human life. These years have seen the development of the telephone, the automobile, the airplane, motion pictures, rayon and radio.

The last twenty-five years have also seen a radical change in the coördination of cost control and accounting technique. Quickness of communication has speeded up the acceptance of new ideas. Painstaking research is going to produce still greater advances in costing technique. Much has already been done for the further refinement of factory costs and for ultimately tying in the analysis of selling expense with book records. As yet sales accounting analyses seem to be useful only over a period of several months and are not as yet tied in with monthly cost control.

At best costing technique is largely founded on "still pictures" of a business; for instance, a normal burden is selected for an assumed normal level of business. This is not always adequate for a business with rapidly and widely fluctuating volume. Perhaps the future may provide a really good technique for making our cost reports into a "moving" picture of what is going on in a business. There is much room for progress.

ENGINEERING TRAINING FOR THE OPERATING WORK OF INDUSTRY*

By DONALD S. BRIDGMAN

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In defining the words "operating work," for the purpose of this discussion, it seems desirable to interpret them somewhat broadly as covering participation in, or supervision at any level of, the construction and maintenance of plant, as well as the actual production of goods and services. Staff assistants to operating supervisors or executives, concerned with analyses of results, adaptations of accepted methods to particular situations, personnel matters, and the like, will also be considered as engaged in operating work. In public utility companies generally, employees responsible for business contacts with customers, including sales, presumably are also a part of these operating divisions; certainly that is true in the Telephone Companies, but it is not likely to be the case in other industrial organizations. Men engaged in research, development, and design, or in accounting and financial control, are clearly not in operating work, nor generally are those concerned with the planning of a company's plant, although many of the latter must have constant and intimate contact with the operating organization. My interpretation of operations, however, would bring into it a high proportion of the men in general management and administrative positions.

On the basis of any such definition, the surveys of engineering graduates during the past twenty years place a most substantial proportion of all engineering graduates in the operating work of industry. The survey of this Society's Board of Investigation in 1925 would so classify about a third of the younger graduates and, because of the increasing number of management positions, a far higher proportion, probably more than one-half, of the older graduates whom it covered. The report of the American Society of Mechanical Engineers' Survey in 1930 indicates a similar trend with increasing maturity and states that, of the group included over 32 years old, more than two-thirds were in industrial management as distinguished from industrial technician positions. Presumably because of depression conditions, the 1934 data of the Bureau of

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Labor Statistics secured in coöperation with the American Engineering Council generally show much higher proportions of the younger engineers in operations, although the proportion of the older men in management is smaller. At all ages, however, at least two-fifths and, in some groups, more than half of those covered were engaged in operations, construction, and management. Of all engineering graduates in the Bell System Companies today, about 30 per cent are engaged in distinctly operating work and perhaps 25 per cent more in engineering work so closely associated with operations that constant contact with it is essential and transfers of individuals to it may occur.

On the whole, it seems to me that the data available indicate that not less than half of all engineering graduates have spent a substantial part of their working lives in operating work and, although today the defense program is making tremendous demands on the engineer in highly technical fields, in the long run I should expect that the proportion of engineers engaged in operation or management would increase rather than the reverse. During the twenty years from 1920 to 1940, the number of all first degrees given to men increased 200 per cent, the number of engineering degrees 160 per cent. Population on the other hand increased but 25 per cent and the volume of industrial activity only 35 per cent. As high school graduation has increased far more rapidly than that from college, continued increases at the college level seem likely and an increasing range of activities for all college graduates essential. For the engineering graduate, this implies a growing need to find an outlet for his education and capacity outside the distinctly technical fields.

Another aspect of this question is the growing dependence of industry upon the engineering schools. The increasing proportion of the country's young men graduated from college inevitably has reduced the number of outstandingly able non-college men, although that number is still substantial and it is of vital importance that industry make full use of their capacity. As industrial processes have become more complex and more dependent on the applications of scientific and engineering principles, it becomes more difficult to find, outside the engineering graduate group, men whose interests and training equip them to supervise the operations of such processes. There are some such men among the graduates of other college curricula, (and far more could be done in the colleges of liberal arts and of business administration to promote a broad understanding of the technological basis of our industrial civilization), but their numbers are small and the principal source of well trained, competent leadership in industrial operations should be the engineering college.

In the operating phases of even a distinctly technical business, such as the Bell System, to the research, development and engineering work of which engineering graduates have made wholly decisive contributions, the proportion of important leadership positions held by such graduates is today somewhat less than might be expected. In the Western Electric Company and Operating Telephone Companies, only about half of such positions in the executive department, the operating departments, not including commercial or sales, and the engineering departments, which in those Companies are closely associated with operations, are held by college graduates and of those graduates, less than two-thirds took their degrees in engineering. In the Operating Telephone Companies, moreover, careful analysis of salary progress, department by department, indicates no significant differences between graduates of engineering and of other college curricula, although it is true that the early losses of men from the other curricula are definitely larger.

The clue to this situation and to the problem under discussion may lie in consideration of the principal differences between operating work in industry and work of a more technical character. Obviously, the chief of these differences is that the operating work demands for its performance substantial numbers of men and women whose selection, training, organization and leadership are major responsibilities of the management forces in such work as contrasted with the emphasis on the properties of materials and mechanisms in research and development and engineering planning. The proper determination and control of costs are essential factors in both fields of work but, even in more normal times, those which do not depend on morale as an element in productivity are likely to be least in error. An appreciation of the decisive importance of such intangible factors and skill in dealing with them is of the essence of success in operating work.

To say this is not to depreciate the value of the engineer's technical knowledge and skill which contribute to the efficient organization and performance of any task to be carried through by his subordinates or associates. The opportunity for steady production based on a properly organized process, good tools, and a smooth flow of materials is an essential element in respect for the boss and cooperation with him. Only in rare instances, however, does it seem likely that this requirement will not be met by engineering graduates who have real mastery of mathematics, physics, and the basic engineering courses in their chosen field, plus the ability to apply the analytical or engineering method of attack to any new problem. That real mastery of such fundamentals is important is indicated by the fact, shown by the studies of college graduates in the System, that men with good scholastic records make the best progress in line

supervisory work, as well as in that of a staff or engineering nature, even though more of the better students are found in the latter fields. It seems clear that other things being equal, the flexibility of mind, grasp of the essentials in a problem and orderly habits of thought which result in good scholarship are useful in solving human as well as technical problems.

A somewhat more distinctive requirement for operating work is an awareness in the engineering student of its existence, its opportunities for the individual, its importance to society and an acceptance of the initial hardships it may impose. Too often, the abler students particularly have little appreciation of the significance of these things for themselves and have directed their interests almost solely to the applications of their education in research, development, or design where it seems to be most directly useful and to afford the chance of creative work. By contrast, employment in a craft to gain the skill and understanding of the workers essential for a first line supervisor seems a plodding method indeed and the value of such experience to the superintendent or general manager is most obscure. A recent study of major executives in the Bell Telephone Companies indicated that line supervisory experience has been the major component in the background of the large majority. It would be absurd not to recognize that a highly technical interest is often the inevitable result of interests and abilities which have brought the students involved to an engineering school and in those cases an effort to divert them would only make poor operating men out of those capable of real scientific achievement. In other instances, however, stimulation of awakening social interests in the broadest sense may lead men who understand the technology of our civilization to places where, to paraphrase President Doherty, the effectiveness of the engineer's method, the objectivity of his approach, the impartiality of his decisions and firmness of his execution may contribute greatly to critical economic and social problems of today and the future.

To this end, I can do no better than to endorse wholeheartedly the recommendations of the Committee on the Aims and Scope of Engineering Curricula especially in respect to the development of a humanistic-social sequence of studies, paralleling the scientific technological studies throughout the four-year undergraduate period. The continuity of such a sequence, without the break of even a semester, seems to me essential if its objectives are to be even approached and the importance of qualitative, as contrasted with quantitative, of human, as contrasted with material, values in society and in life is to be appreciated in any adequate fashion. In the development of this sequence, moreover, some attempt to shift gradually from the rather practical and factual content of

English composition and history, with an emphasis on its institutional elements, toward the more abstract and imagination—stretching elements in economics, labor problems, psychology, literature, and even philosophy might be most in harmony with the developing interests of your students. In saying this, I am only repeating the ideas of an able Law School Dean, who, some years ago, hoped to admit students after two years of liberal arts, and to come back, at the end of a four-year course in law school, to such studies as government, sociology, and philosophy.

Such an order might sacrifice something of the polish which a senior course in Engineering Report Writing might give, but I should be skeptical of the lasting quality of that polish if previous courses throughout the curriculum had not established the habits of logical thought and orderly presentation. In addition, a greater sacrifice would be worth while if at that stage the students learned to appreciate the simplicity and vigor of style in great literature. Written or oral reports that influence major decisions of policy must be not only precise but persuasive with the sweep of language which compels attention and arouses imagination.

It is instructive to consider the Committee's recommendation in the light of D. C. Jackson's recent report of Trends in Engineering Education. The charts it contains analyzing the content of the electrical, mechanical, and civil engineering curricula over 50 to 60 years indicate that, in 1934, the final year shown, all three curricula devoted the equivalent of somewhat over two years to specialized engineering subjects, about one full year to mathematics and the physical sciences, certainly no more than one-fourth of a year to electives and only one-half year, or one-eighth of the total, to humanistic-social studies. To what extent their allotment has been increased since 1934 is not revealed but it seems self-evident that realization of the Committee's aims will demand substantial action in that direction.

Although the Committee's recommendations are in terms of broad objectives for all engineering students, the means for their realization will certainly differ greatly for individuals, requiring substantial freedom of choice with regard to specific courses in accordance with the tastes and aims of the student. If such choices are to be made wisely, some colleges may find it important to provide more counseling assistance than has seemed necessary in the past. In most instances, with such assistance, students should be able to determine in sophomore or junior year whether their abilities and interests will find their best outlet in work of an operating or of a more highly technical nature and steer their later course accordingly.

Although their importance is clearly implied in the Committee's report, those subjects which bear most directly upon understanding of the nature of man as an individual and as a member of the group are not explicitly mentioned. I have already suggested that cooperation with and leadership of men is the most distinctive element of operating work and in closing, I should like to revert to that point. Surely the development of competent men, to say nothing of true leaders, in this field is not primarily a matter of book learning. Much of it results from the experience of working shoulder to shoulder with men in the working force on a common task, at least in the early years after graduation, if possible in one or more summers or coöperative periods before it. Possibly even more may come from the self-confidence and personal security which results from a happy childhood and which makes other men comrades rather than rivals and threats to one's prestige. But, granting all this, study of the bases of human behavior, of the motives and emotional needs of men cannot fail to sharpen the sensitivity and awareness of many students. Psychology, including some insight into the abnormal, and sociology may provide the necessary foundation, but the rise of labor unions and some of their tendencies may well be studied from this point of view as well as from that of their economic goals. The studies at the Hawthorne Plant of the Western Electric Company illustrate how methods of dealing with problems in human relations which were instinctive in a few supervisors may be understood and adopted by many others.

I stress this point because of my deep conviction that the stakes for our civilization may be won or lost by our wisdom and vision or blundering and blindness in dealing with such problems, no less than by our ability to aid effectively in halting the march of totalitarian conquest in Europe. I should like to share that conviction with every engineering graduate who hopes for a position of leadership in the operating work of industry, and shall try to make clear what I mean by a quotation and some observations from a talk on a different occasion.

In a recent discussion of Tocqueville's "Philosophy of Freedom" in the *Review of Politics* there appear these sentences:

> Their analyses (Tocqueville's and Scheler's) of the transformation of man in society stress the slow decay of general standards of human personality and of human grandeur. They watch the rise of a mass society, the trends toward leveling, toward uniformity and toward standardization, that seem disintegration to the thinker who still applies the criteria of an aristocratic society. However, the philosopher who meditates the wisdom of the Divine Providence will justify this general leveling as the historical price mankind has to pay for the gains of social justice and freedom for self-realization.

Three-quarters of a century after Tocqueville, Ortega y Gasset in "The Revolt of the Masses," wrote of today's primitive man who requires nothing of himself and demands the fruits of civilization as a natural right, with no feeling of responsibility for their creation and renewal. Inevitably such an attitude must lead to mass intervention through direct action and, as merely the next step, to the all-powerful state. One need not be an alarmist to see steps in this sequence here but if we honestly believe in the basis of democracy, we may not seek to halt it by denying to any man his chance for his fullest development as a human being based in part on all the freedom from poverty and insecurity which society can provide. We may only strive to build in all men such a sense of participation in our common enterprise that they will gladly share responsibility for it. In doing so, we dare not yield to selfish group pressure and must rely on man's capacity to meet the truth if we can but make it clear. The dictator despises his people through belief in the power of chicanery and propaganda over them but is afraid to trust such means alone and calls on terror of the concentration camp and the firing squad. He survives by success in achieving ends and cares not for his means. True leaders of democracy believing with Emerson that "the ends preëxist in the means," may count only on their faith in man's integrity as they seek his allegiance. Only by that road, will the rise of a mass society lead not to the decay of human grandeur but towards its fulfillment.

PRELIMINARY RESULTS FROM EXPERIMENTS IN TEACHING MECHANICS *

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Purpose

The experiments discussed in this paper were undertaken in order to devise a plan or method of instruction that would result in a greater degree of creative effort, than is usually attained, on the part of at least a selected portion of the students in a course, and also on the part of the instructors teaching the course, without increasing the cost of instruction or decreasing the effectiveness of the instruction to the remaining portion of students in the course. It was also the purpose to devise a quantitative measure of the success of the experiment.

In planning the experiments rather definite assumptions were made as to the conditions required for the stimulation and development of creative effort and since these conditions conform rather closely to those expressed in one part of the recently published "Present Status and Trends of Engineering Education," prepared for the E. C. P. D. by Professor Dugald Jackson, two brief statements from that publication will be used to suggest the conditions, namely:

"The best part of education for youth is to come into contact with stirring personalities that have had great adventures with ideas,"

and,

"Two trends . . . are . . . more responsibility placed on the individual students for self-education associated with more sympathetic and wisely directed supervision, encouragement, and counsel from the staff; and the fuller acceptance, as a tenet, of the significance of research for the education of engineering students during their upper undergraduate years."

These three conditions, student contact with teachers who are in step with the tempo of modern engineering, greater emphasis on self-education, and research as a means whereby self-education may

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be achieved, constitute the *sine qua non* for creative work with a selected group of students.

The many conferences and papers on engineering education in recent years might be expected to eventuate in improved methods of teaching. Yet there are but few reports of controlled experiments in such teaching, carried out on a sufficiently large scale to yield definite results. Each teacher apparently feels that he knows the answer without experiment. In other words teachers seem to feel that we need experiments to determine, for example, the sound absorption of acoustical material but that we do not need them to determine the absorbing capacity of students under various conditions.

This paper proposes to elaborate the teaching philosophy set forth in the opening paragraph and to report on some experiments based on that philosophy. This conception of teaching embodies the belief that it is possible to utilize a wide variety of talents in our instructors in such a way as to tap more thoroughly the potential abilities of our students by providing vastly improved teaching for the superior student (superior in our field), to vitalize the instructor, to provide as good or better teaching than is now being provided for the average student (average in our particular field though possibly superior in some other field), and to do this without increased instructional cost.

In order to get the complete picture before us, let us look first at our teaching background. About a century ago Amos Eaton at Rensselaer Polytechnic Institute and John Norton with Joseph Silliman at Sheffield Scientific School, to mention only two institutions, began their work in teaching engineering and science. In that day the laboratory and the classroom were not as clearly differentiated as they are today because textbooks and laboratory manuals, as we know them, were non-existent. Instructor and student made notes and copied lectures. One result was that,

> . . . students . . . came with earnestness of purpose and with a degree of enthusiasm that kept the laboratory a beehive of activity . . . there were few or no rules . . . but the laboratory, poor though it was, was sufficiently attractive to hold the men through the working hours of the day . . . and far into the night. The . . . work . . . was mainly personal contact . . . where students worked out for themselves . . . first-hand knowledge of the facts and principles. . . ." *

Today the classroom and the laboratory are two different teaching methods each with its own technique. Today, in contrast with

* "Inventors and Engineers of Old New Haven," Edited by R. S. Kirby, pp. 90–91.

this early enthusiastic search for knowledge, the instructor literally bathes the student with facts in the expectation, or at least the hope, that he will absorb some of them.

What of the classroom today? The routine is well established: Classes consist of about 20–25 students who study a standard textbook. Assignments are made in the textbook including a number of problems to be solved. In class the instructor develops the theory as outlined in the text, with elaborations at points which experience has shown to be difficult. Perhaps this routine method answers fairly well for the average student and, under the limitations of large numbers of students, limited funds, and instructors as we have developed them, the best plan we can devise. But what of the few students who show marked ability in any given field (others may show this marked ability in other fields), those whom we may, for want of a better term, call the "superior" students? What of the "superior" instructors who are meeting new experiences and exploring pregnant ideas? And it may not be amiss to remind ourselves that more of our students are "superior" than we think and that many a seemingly "ordinary" young instructor may become a front-rank teacher if only he is given the opportunity and encouragement. We repeat, what about these students and these instructors?

It is obvious that we cannot return to the conditions and methods of a century ago but that does not deny "personal contact" between student and instructor as outlined in our opening paragraphs. What do we mean by "personal contact"? Just this! A "Mark Hopkins" relationship between an alert student and a forward-looking, enthusiastic instructor. With such instructors, is it not possible to arouse the intellectual curiosity of five or six "superior" students in a class where each may feel the impact of mature ideas and then, since this is expensive, to balance instructional costs by handling 35–40 (instead of about 20) students in a recitation class? Certainly, if they are to be effective, the teaching methods will need to be different in the two types of classes. But why not? Some instructors can stimulate and develop initiative and originality in individuals while other instructors will be able to so organize the work that the larger group will be led into an order of achievement at least as great as the average of the present section. But, and here comes the rub, routine teaching and methods will not suffice for either group.

At the University of Illinois we have been trying some experiments both in classroom teaching and in laboratory work. In the classroom we are operating experimental sections of about 40 students, twice the normal size of section, in Strength of Materials

and at the same time sections of 5–6 selected students in Strength of Materials and in Kinetics. These sections have been in operation for three semesters and while the results have been most encouraging we do not feel that sufficient work has been done to warrant drawing other than general conclusions; it is planned to continue these experimental sections. However, we have been operating large and very small (thesis) experimental laboratory sections long enough to warrant drawing conclusions and the rest of this paper will be devoted to a discussion of this topic.

Experiments in Laboratory Instruction

The method used for many years in the Materials Testing Laboratory at the University of Illinois, and which in its general form is used at many institutions, consists in dividing a section into small squads, we use three students in a squad, and assigning an experiment to each squad. The students operate the machines, manipulate the strain measuring apparatus, observe and record the data and each student prepares at home a short report of the experiment. This report is usually due at the next meeting of the class. The normal number of squads supervised by one instructor is three with a maximum of four. Thus the normal number of students per instructor is nine with a maximum of twelve.

The theory involved in this method is: (1) Each student has direct experience in the manipulation of testing machines and apparatus and it is assumed that he thereby "learns by doing"; (2) Each student is assigned a definite job during the experiment and it is assumed that he is led to take the initiative in learning, and (3) he has practiced in writing many reports—one for each experiment—and it is assumed that writing many reports develops his ability to organize his thoughts and to comprehend the significance of the test.

But are these assumptions justified? The "learn by doing" assumption has some real basis but the continued manipulation of similar machines and apparatus, when used as a learning device, gives decidedly diminishing returns. Similarly, the educative value of student initiative and responsibility is rather small because in a laboratory period of two, or even three or four, hours the experiments and the apparatus must be standardized to a considerable degree in order to complete the work in the time alloted. This standardization curtails the amount of initiative which can be used and makes the work routine rather than thought-provoking, stimulating and creative. The writing of short, routine reports, instead

of helping to develop the ability to synthesize and coördinate, emphasizes the performance of small, isolated tasks. From the educational viewpoint this lack of integration or synthesis is one of the greatest defects of the present system.

Such small-squad courses are very expensive in student time, in equipment needed, and, because of the small number of students who can be supervised by one instructor, in instructional cost; with us, testing materials laboratory is nearly three times as expensive as classroom teaching, to say nothing of the overhead in equipment and space. Apparently, however, engineering faculties must consider, without much evidence, that the educational value of laboratory instruction is very large, when carried out in accordance with the conditions just stated, as otherwise the great cost could not be justified and the methods would be changed.

In searching for a solution of the problem, the question is not so much whether the present method is good but whether it is the best possible, considering the cost of time of student, expense for time of instructor and cost of equipment. By the term "best" we mean the method which will without increasing the cost appreciably, take advantage of the special abilities of each instructor, use the equipment which is available and draw out to the highest degree possible the variety of abilities latent in the student. While the present small-squad method may be good, the question is raised as to whether the three assumptions postulated in small-squad work are justified to the degree that each student needs to carry out the work in every laboratory course according to this pattern in order to get the maximum over-all benefit from all laboratory courses. We believe that our laboratories might be used to better advantage if some students were doing this routine type of work while others were doing a greater amount of self-directed, creative, investigational work in close contact with a provocative instructor.

Accordingly, to emphasize the self-directive part of laboratory work we have been stressing thesis work, usually a part of a live, research problem, for a few senior students. This small-section work (one student in this case) by a few selected students was, it will be recalled, one of the prime objectives stated at the beginning of this paper. Of course only a relatively small number of students will select a thesis, which is as it should be because only a small number of students will have definite ability in and have their imaginations stirred by any particular topic.

Thesis work is an experiment with us and some may frown upon it because there is no real objective test of its effectiveness. We feel differently and believe we have been able to, in some degree evaluate its worth. One evidence of the high character of the

work done by these students who have elected theses may be cited; of some forty-odd theses in five years, portions of fifty per cent of them have been published in bulletins or technical journals.

To balance this intensive and, for the instructor, time-consuming teaching, we are now using for some classes a discussion-demonstration type of laboratory instruction in which less manipulative work is done by the student than in the regular small-squad course. It is assumed that in other laboratory courses these students will do the usual manipulative type of work and it is hoped that some of them will do, in other courses, the more self-directed, research type of work such as is involved in thesis investigation.

The discussion-demonstration sections, which are twice as large as the small-squad sections handled by one instructor, are conducted by one instructor with the aid of a number of students. The students are seated around the machine on which the experiment is to be performed and a blackboard is placed conveniently near. The instructor first discusses the general character of the group of experiments being performed, *e.g.*, plastic action of materials, and then describes the character and purpose of the particular experiment to be performed, *e.g.*, a study of strain hardening. He calls upon two or three students to operate the machine and take readings, which are often plotted on the blackboard by a student. The other students record the data, which are often plotted individually and analyzed in class. Frequently two or three groups of students are used in turn as assistants in one period. The work of the course, one period per week per semester, is divided into four parts with a report made by each student on each part or group of experiments.

During two periods each semester the discussion-demonstration sections perform experiments in the same way as the regular sections, *i.e.*, they operate by squads. This is done to allow the students to handle a testing machine and instruments all by themselves and thus satisfy a natural desire to "run the machine." Likewise for three periods the regular small-squad sections are conducted as discussion-demonstration sections on experiments which it is not feasible to conduct by squads.

Results of Experiment

The discussion-demonstration type of work has been conducted for nine semesters by five different instructors in parallel with the regular small-squad sections. There have been 681 students in the discussion-demonstration sections and during the same period 1214 in the regular sections. The distribution is as follows:

Year	First Semester			Second Semester		
	Number D-D Sections	Number Students in D-D Sections	Number Students in Reg. Sections	Number D-D Sections	Number Students in D-D Sections	Number Students in Reg. Sections
1936–37	—	—	—	2	49	81
1937–38	4	92	136	4	95	105
1938–39	6	126	158	4	84	113
1939–40	4	92	182	2	32	134
1940–41	4	63	192	3	48	113
TOTALS	18	373	668	15	308	546

The first three semesters this method was used we administered no objective tests to the students to compare the results obtained by the different types of instruction. But beginning with the first semester of 1938–39 an examination was devised which has been given to all students since that time. Since all students, regardless of the type of instruction, write the same examination it should furnish evidence of the relative effectiveness of the instruction by each method.

The examination is a written one, two hours in length, which involves a large number of questions of various types. Three sets of questions, *A*. *B* and *C*, similar in general outline, were formulated with great care by a committee and criticized by all the laboratory teaching staff; the questions were revised after being used the first time. The questions in this examination embody those elements which the teaching staff feels should be known by students taking the course, regardless of the method of teaching, and the same questions have been used for five semesters, the three sets being used alternately for all sections each semester. The students are not allowed to take away any of the examinations, doing all work on paper given to them, and there is no evidence that knowledge of the content of the examination passes from one student to another. In order to secure uniformity of grading, the papers are graded by all the instructors teaching the course, each instructor grading the same type of question for all students in any one semester but grading a different one the next semester.

In addition to computing average grades, the examinations for the past five semesters have been analyzed in considerable detail according to the type of question and this analysis is reported in the table entitled "Analysis of Grades for Type of Question." The three examinations, *A*, *B*, and *C* could not be distributed with complete uniformity in any semester and therefore only the grades

ANALYSIS OF GRADES FOR TYPE OF QUESTION

Type of question	Semester and year	Average Grades									
		2d, 1938–39		1st, 1939–40		2d, 1939–40		1st, 1940–41		2d, 1940–41	
	Type of teaching Number students	Reg. 69	DD 77	Reg. 110	DD 101	Reg. 31	DD 32	Reg. 192	DD 63	Reg. 46	DD 45
Grade on written lesson		78.2	77.8	72.2	76.7	81.1	80.4	78.0	79.1	79.9	82.5
Procedure for making test		73.8	73.4	71.0	76.0	82.2	80.0	58.0	62.7	66.9	75.6
Selection of correct word from a number given		71.2	72.8	76.3	80.8	80.2	81.6	73.3	78.1	80.4	87.1
Selection of properties and material needed for a given purpose		71.6	66.3	64.0	75.5	70.1	68.3	71.7	76.8	77.6	75.3
True-false statement		81.2	81.3	68.5	73.7	83.4	74.3	78.5	81.3	82.4	77.6
Discussion of given topic		54.3	54.6	76.4	79.5	79.6	84.1	74.7	72.8	77.8	82.0
Fill blank space with correct word		71.1	73.3	64.6	65.5	73.4	75.9	72.7	74.0	73.1	79.2
Plot and analyze data		85.8	85.6	74.3	78.8	85.6	85.1	85.3	86.7	86.6	89.1

of those students who took the same examinations are included. It will be observed that, with a few exceptions, the "Grade on written lesson" for any given semester is practically the same for each type of instruction. The weighted average for the regular sections is 77.0 and for the discussion-demonstration sections is 78.7.

In making comparisons for the different types of questions, such comparisons should be made only within any given semester and not between semesters. For instance the grades on the question "Discussion of a given topic" for the 2d semester, 1938–39, are far below those of any other semester though they are the same for both types of instruction; it seems obvious that the instructor who graded that question in the 2d semester, 1938–39, had distinctly different views as to what constituted an adequate discussion from those held by the instructors who graded that question subsequently. In addition to the analysis on the basis of type of question, the papers written in the 2d semester, 1938–39, were studied in considerable detail with respect to the content of the question. Except for minor variations there was no significant difference in the achievement of either group in understanding the different topics studied.

Since the averages of two groups may be quite similar and yet contain wide variations in the different grade levels, the numbers and percentages in the various grade levels for examinations *A* and *B* were determined and are as follows:

		Total No. Stud.	Ave. Grade	100–90	89–80	79–70	69–60	59–50	Below 50
Reg. Section	No. stud.	279	76.0	32	140	116	69	20	2
	Per cent			8.4	37.0	30.6	18.2	5.3	0.5
D-D Section	No. stud.	241	78.9	33	94	70	36	8	0
	Per cent			13.7	39.0	29.1	14.9	3.3	0

This table shows that in the regular small-squad sections there were 45.4 per cent of the students who wrote 80 or above on the examination while in the discussion-demonstration sections 52.7 per cent made a grade of 80 or above. A study of all the data seems to warrant the conclusion that the instruction given in the discussion-demonstration sections is at least as effective, when judged by a written examination, as that given in the regular sections.

One other element was considered, that of the reaction of the students to the two methods of teaching. It will be recalled that the regular small-squad sections had three discussion-demonstration

periods while the discussion-demonstration sections had two squad periods, consequently each group had some experience with both methods of approach. With each examination a sheet of paper was given to each student and he was asked to state which type of section or method of approach he preferred and why. He was told that the answer in no way affected his grade in the course and he was asked not to sign the paper.

The responses to this question varied but in general about two thirds to three quarters of those in the regular sections preferred the squad type, largely because they felt they could understand the work better if they "handled the machines and materials" and because they "had to work the experiment themselves." The remaining portion preferred the discussion-demonstration type because they felt they "got better data" and "had difficult points explained as they went along." With the discussion-demonstration groups the reasons were the same but the percentages were reversed. Thus the majority in each group preferred the type of instruction to which they were accustomed.

Summary

This paper has presented a teaching philosophy and the results of a careful study of experiments based on that philosophy. The principal points set forth are as follows:

1. Engineering instruction has changed from an intimate face-to-face, question-and-answer discussion between instructor and the individual student into a treadmill, routine performance of small tasks.

2. There needs to be a revival of and a stimulus toward more creative work, more intellectual curiosity, on the part of both the student and the instructor. Evidence shows that, under proper conditions, this can be accomplished by both alert students and enthusiastic instructors.

3. Research, by means of theses on live, pertinent engineering problems, furnishes, for a selected group, an excellent medium through which creative, self-directed education is achieved, but it is expensive in instructor time.

4. Teaching experiments show that laboratory instruction can be carried out as effectively in large sections by the discussion-demonstration method as in small-squad sections only one half as large and hence this method decreases expense.

EVALUATION OF RESULTS FROM DIFFERENT TYPES OF EDUCATIONAL PROCESSES*

By FOREST C. DANA

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When I entered the teaching profession in the college of engineering in a west coast university after spending a number of years in industrial work, I was impressed at once by the well nigh complete absence of uniform or consistent methods of evaluating the achievement of students in their daily work. The so-called objective tests were popular then, as now, with teachers who were mainly concerned with fact impartation and absorption. In engineering, however, telling is not teaching, nor is hearing the same as learning; the ability to do is as important as the knowledge of how to do it. Now a large portion of the work assigned to the engineering student consists of problems and reports. They range through problems in statics and dynamics, strength of materials, hydraulics, drawing, descriptive geometry, to reports on technical designs, cost estimates, and problems in engineering economy.

It seems to me that objective tests have scant, if any, place in work of this type. They merely measure achievement on the test itself, or at best some of the incidental facts absorbed during the main study. They certainly *do not* measure the quantity and quality of the work done on the original assignments. Some other approach must be devised if we are to rate students on the numerical results, mathematical approach, judgment, and workmanship involved in daily assignments.

This problem of grading intrigued me, probably because I was so new to classroom life and thus I began to ask questions and to read to see what others had done to improve grading procedures. Not much seemed to have been tried at that time but that little indicated there was wide variation in the grades given by two or more men to any given paper. A few informal (and unsuspected) tests given to my colleagues verified this conclusion, and led me to suspect that it is a rare thing for any two teachers to give the same grade to papers that are, in fact, identical. There are also term to term variations in the grades assigned by any one instructor.

* Presented at the 49th Annual Meeting, S. P. E. E. (Instructional Methods), University of Michigan, June 23–27, 1941.

Sometimes such variations are found from class to class in the same term, with the same teacher. Where scholarships and honors are involved such variations may well result in injustices to students.

I think I am correct in saying that in most engineering schools, every teacher is complainant, jury, judge, and executioner, so far as grading his student's work is concerned, regardless of the fact that there may be one or a dozen colleagues teaching the same subject, the same time, and to the same unsorted types of pupils. As with most free-lance workers these teachers are seldom consistent in their own private methods of grading.

It was also noteworthy that most of the older teachers resented any questions and experiments that tended to cast doubt on the validity of their grades, and they evidenced a rather pathetic trust in the accuracy of their verdict when they gave a student a grade of 94.9 and insisted that the victim of their averages "was not quite an A man." Yet in some cases I had actually seen them arbitrarily raise or lower a daily grade by as much as 10 to 15 per cent.

This unquestioning use of "rubber yardsticks" in measuring educational progress is disturbing to one who is familiar with the exacting standards of measurement in industry, and explains why the writer has long been experimenting with grading schemes in the effort to find some way of doing a better job of scoring engineering computations and reports. He cannot claim to be an authority, but merely reports that progress has been made and feels that grading can be improved even if it still has many inaccuracies.

A great many of the problems assigned in engineering are more or less mathematical in their nature and so the following description of the courses used in this study, the nature of the experiments made and the final system we adopted may be of value to various other teachers.

Engineering as contrasted with law, medicine, surgery, and other professions, is one in which the practitioner is expected, both by his colleagues and the world at large, to be well qualified in several apparently unrelated types of activity. The lawyer, for example, is expected by most people to be familiar with the hair-splitting distinctions of the legal code, but no one cares at all whether or not his notes can be read by another person. The engineer, however, must not only know the details of technical theory and physical laws, but his calculations must be accurate, he must adhere to the profession's codes of specifications for drawings and materials, he must be neat and systematic, and his office records must be models of clarity. He holds a semi-legal status and his records

may become legal evidence at any time, hence they should be without doubt or error.

Many engineering schools have found it advisable to develop courses in which special training is given in the making of engineering calculations according to specific standards. Most of such courses are conducted on a laboratory basis in order to give students ample working time under the supervision of a trained engineer who coaches them on methods, forms, codes of symbols, standards of workmanship, and systematic arrangement of records. The following report concerns a research project using such a group of courses as a field for conducting a study of grading methods. Sectioning of classes in Engineering Problems was attempted soon after I came to Iowa State College but it was an utter failure because instructors gave as many high grades in the lowest sections as they did in the top sections. Objective tests were found to be worthless for grading and sectioning because they merely measured fact absorption while we were concerned with numerical calculation, neatness, and standards. No satisfactory objective tests were found to measure the skills needed in practical engineering calculating and in the recording of the numerical work. In these calculation classes effort is made to induce the student to reason his way through his problem, to choose efficient methods of solving it, to have him use skill in mathematical operations, and moreover, to submit his work in engineering lettering, neatly and systematically arranged on standard forms, and using recognized codes of symbols and abbreviations. Thus workmanship becomes a highly important factor to be measured. Another element that vitally affects the student's later career is his working speed. Not only must he be accurate, neat, and systematic in industrial fields but he must be able to produce a satisfactory amount of work per day.

An acceptable scoring system for work of the type described has to meet several exacting requirements. First, it must induce a favorable emotional response on the part of students. Second, it must be impersonal and impartial. Third, the system must be flexible so new situations or problem changes may be handled easily. Fourth, the actual scoring must be as simple as possible to keep clerical costs down and avoid the necessity for using highly skilled help. Fifth, it must be reasonably accurate so the scores obtained will permit the ranking of students in a given subject without regard to section or instructor.

During the year 1931–32 experiments were made in developing a detailed record sheet that would show just what parts of problems were the cause of student troubles. A sheet was finally devised that worked out so well that the record on it was used in later ex-

periments looking toward a new scoring system. During the fall of 1932, the daily records of some 300 students in earlier classes in a ten week Engineering Problems course were revalued by Mr. George C. Ernst, my assistant at that time, on the basis of various possible "point" systems as contrasted with the percentage scores. We tried four schemes involving the figuring of over 12,000 scores, getting term rankings, and then assigning grades. The plan showing the greatest promise was adopted tentatively for actual trial in the winter and spring of 1933. We thus obtained scores on over 750 students and 7,500 to 8,000 papers. After two quarter's use the plan was checked, modified here and there, and definitely adopted for all the courses in the fall of 1934. It has now been in use in one department in the present form for seven years; on five different subjects, and for over 9,800 students. To date approximately 100,000 student papers have been evaluated on this "point" basis. The weightings given to some problems or parts of them have been revised now and then as experience indicated such changes to be desirable, but the general program has been unchanged for several years.

The basic features of the system are as follows:

a. Uniform computing time is alloted on all problems that are to be scored. A portion of the class period is set aside for demonstration, discussion, experimental calculations, or answering student questions. This gives full play for the personality of the instructor in his teaching. The computing time, however, is not broken into by further instructions unless some serious trouble is encountered by the majority of the class. An instructor's time schedule is prepared for each period showing the suggested division of time for general instruction and the length of the fixed computing times.

b. The checkers who correct the student's papers are supplied with master copies of problems, templets for graphic work, and specification summaries. All problems have the tolerances on the answers carefully worked out in accord with the precision of data and the computing method used. Answers to each step thus can be checked accurately, quickly, and consistently, from class to class. The checking staff is large enough so papers from a given section are not likely to be corrected by the same man week after week.

c. Each type of work, each problem, and each partial answer at each step in the solution of a problem is weighted and the "pointing" assigned by a committee from the staff. For certain stock operations a uniform measure in "points" may be given and used in all problems. For example, a two or three factor problem solved by logarithms is worth ten points if no interpolating is done, but 20 points if interpolated. In the first case when the answer is

wrong each correct logarithm receives 2 points, but if interpolated it receives 4 points. The work is watched carefully in the first classes to work on the new problems and necessary changes in the pointing are made at once before any papers are scored.

d. To coach the students in developing habits of neatness, system, adherence to standards, and other habits that may be included under the general heading "workmanship," each specification ignored by them is called to their attention by writing its number, in distinctive color of pencil, somewhere near the error. Each man is expected to refer to the list of specifications to see where his neatness and workmanship is not up to the standard.

e. It is highly desirable to have student approval of any rating system, whatever it may be, and we have secured almost unanimous approval of the present system by abandoning all penalties for errors and deductions for unfinished parts of the work. A student is credited with any points assigned to the portion of his problem that he has handled correctly. A system of bonuses makes it possible for him to build up a reserve or overcome an earlier low score. The slow student receives credit for all of his correct work, and the fastest student for all of his, but the presence of either type of pupil in a class does not affect the score given to the others. Thus the "lid is off" for the fast men, they can go as far and fast as they can without making the pace hotter for the slower men.

Because workmanship is so important we give a bonus for good work. The workmanship score is in letter form, A, B, C, etc., on the student paper but we actually add bonus points to the results score to get his total grade. The smaller the number of specifications called to his attention the larger the bonus. If a student has 7 to 9 specifications noted we accept the work, but do not consider it worth a bonus. As he improves the bonus increases from 10 per cent for five specifications to 30 per cent for one or none at all. The bonus is figured on the total points of correct results, not on work attempted, so the pressure is on the obtaining of correct answers as well as on speed, neatness, and standards. If ten or more specifications have been ignored or certain single ones regarding scribbling, mushy pencils, etc., we reserve the right to turn the paper back for rewriting. If the second copy is acceptable the student receives full credit for his results but naturally no bonus is given. A 10-point bonus is also given on slide rule drill sheets if he has 5 consecutive problems correct and 30 points bonus if he has 10 in a row. Since the total bonus can be raised as speed and accuracy improve there is a powerful incentive for the student to increase his working speed and to learn improved computing techniques. The slower student can increase his total score, however, by doing his smaller amount of work accurately and neatly.

An important part of the system is the series of record sheets used by the staff. There are four of them, as follows:

1. The daily schedule for work in class.
2. The daily score sheet for recording student achievement.
3. The term summary.
4. The record of daily medians for all classes.

The daily schedule has been mentioned previously. The daily score sheet is arranged to give a complete record of the day's work, including class identification, problems given, the points assigned to each step in the solution, the record of each student, and the median. The form is arranged so the record also makes a type of bar chart that indicates the volume of work attempted by each student. The spots where most students found trouble also show up at a glance, and we can quickly compare classes for maximum and average speeds.

The summary sheet for the term replaces the old, bound grade books formerly used and an entire year's record for 1,600 students can be filed in one ordinary manila folder, some 60 to 75 sheets of $8\frac{1}{2} \times 11$ paper.

The record of class medians is kept in the departmental office where each instructor records his median and high scores as soon as each set of papers is finished. This report enables the staff to keep a constant check of the various sections, locating the good and the poor ones, and indicating places where more attention is needed. Variations in the medians are expected, of course, but when an instructor's medians begin to run uniformly high or low we all know something needs looking into. For example, if they are too high he has either made a mistake in scoring or he has found a more effective method of presenting the subject. This record is also of great help in grading "off quarter" sections. These usually have a high proportion of poor students, men who have failed or postponed subjects and are out of step with the regular program. This helps us to keep our letter grades meaning the same thing throughout the year.

Students naturally wish to know whether they are doing acceptable work or not and generally think they know how to interpret percentage scores. The point system, however, is new to them and so each day we tell them the high and median scores for their group for the previous week. If available, we also tell them the ranges of these scores for the other sections. The ranking list or grade record for the entire number registered in the course is posted three or four times during the term, usually at the end of the fourth week, at midterm, at end of quarter, and sometimes on the eighth week. We believe that rank and grade are confidential matters between

the department and the student, so we assign each student a code number the third week, and this is used in lieu of his name when we post the lists on the bulletin board.

The technique of handling the paper work in this system has been developed to the point where we use a staff of six part time, undergraduate checkers to correct all papers. They are under the supervision of a senior who has the responsibility of seeing to it that all sets of papers reach the instructors in ample time for scoring them. The actual grading is done by the instructor who uses the master weighting sheet prepared for each problem, this work takes 30 minutes for a 25 man section, including the report on class median, etc. The checker foreman has also been taught how to score the papers and helps out in case an instructor is ill or overloaded. The accuracy of the method is seen in the fact that several sets of papers were independently checked by the foreman and myself and I found that our scores differed on but one paper in 40 and this was only 5 per cent on that one, or about 5 points in 1600 involved in the papers checked. This means, then, that we can be reasonably sure that no injustice will be done to any individual by the end of the term when the cards for all instructors are put into one pile and ranked according to points earned.

The midterm summary for a typical term showed that the maximum variation of any instructor's median from the over-all median was 1.7 per cent. The median scores were as shown in the table below:

Total number of students in course—453

Instr.	No. of Sections	Range in Median Points	Instr.'s Median Points	Median for 453 Students' Points	Difference	
					Points	%
A	5	573–676	629	630	−1	0.17
B	5	592–692	634	630	+4	0.63
C	5	616–653	624	630	−6	0.95
D	4	618–670	640	630	+10	1.7

We do not always hit as closely as this and so it is sometimes necessary to make corrections, but we find the staff works as a unit, comparing methods, students, and evaluations of work as never before. Best of all, they have become more critical of their own measurements and methods.

When the cards have been ranked it is easy to cut the pile into the desired percentage distribution of the letter grades. Minor shifts of a few cards one way or the other are made if the break comes in a group of cards that differ only two or three points.

The staff members have applied the general principles of this "point system" to the scoring of problems in engineering economy, in valuation, estimating, report writing, graduate work in graphic methods, in mechanics, and in hydraulics. Experiment is necessary to determine the unit calibrations on the scale for any subject, but once this has been done the grades of two or more instructors become comparable.

The writer has not used the system on "story" or discussion types of reports but sees no reason why it could not be used on part of the scoring, at least.

In conclusion I can say that the system is working so well in the General Engineering Department that its staff members would be very reluctant to go back to the older, impressionistic method of assigning grades and so I feel I am safe in saying that, for engineering calculation courses at least, we have made some worthwhile progress in developing a fair, uniform, and reliable method of evaluating student achievement.

FUTURE PROSPECTS FOR EMPLOYMENT OF AERONAUTICAL ENGINEERS *

By JOHN D. AKERMANN

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Preface

If anybody, at this stage of aeronautical development, would try to predict the exact number of aeronautical engineering graduates who would be placed on jobs in the near future he would be undertaking an impossible task. Even individual companies, when asked how many aeronautical engineering graduates they will need next year, are very reluctant to give definite answers. Some companies who a year ago this summer were confident that they would have a big enough supply of aeronautical engineers and aeronautical draftsmen changed their minds past winter and therefore, the period of the emergency, giving it a broad and indefinite meaning, could be disposed of very easily by a statement that as long as the emergency lasts every aeronautical engineer will have at least three or four offers for employment in private industry or with the government services. How long this emergency will last I would not dare to guess but even if the European conflict ends today the strengthening of our air forces and commercial air lines would keep on going for at least four or five years in order to bring up our air forces and our commercial planes to the standards which we realize now that our nation needs.

Since the period of the emergency is indefinite, the period after the emergency is still more indefinite and therefore only generalities can be forecast and no attempt should be made to arrive at definite figures for the employment of aeronautical engineers.

By observations and analysis of the past we might make some estimates for the future. In order to do this I am submitting only some individual cases for generalization.

In 1931, in a midwestern state I applied for registration as professional aeronautical engineer. In answer, I was told that I should register as a mechanical or as a civil engineer because "aeronautical engineering is 50 per cent mechanical and 50 per cent civil engineeering," to which statement I replied that 100 per cent mechanical and 100 per cent civil engineering still would not make an aero-

* Presented at the 49th Annual Meeting, S. P. E. E. (Aeronautical Engineering), University of Michigan, June 23–27, 1941.

nautical engineer. That same Board in 1939 registered aeronautical engineers as a separate recognized profession.

In 1941 the National Headquarters of the Selective Service System issued a letter to all State Directors with a list of engineering students to be considered for deferment, naming civil, electrical, chemical, mining, metallurgical and mechanical engineering, but not a word was said about aeronautical engineering or any other branch of the aviation industry. On my telephone inquiry to the National Headquarters of the Selective Service System I was told that the list had been prepared on recommendations of certain, patriarchal engineering advisory counsel which made the omission of the aeronautical engineering. This was corrected later in a special bulletin concerning aviation industry separately.

A certain large aviation concern in the early thirties took pride in scorning aeronautical engineers and employing mostly mechanical and civil engineers. This company, in 1939 and 1940 paid heavily in human lives and in the form of produced inferior models of aircraft. This particular company now is the one who makes the most attractive offers to graduating aeronautical engineers but the best graduates who have several offers are hesitant to connect with that company and prefer to accept employment with other companies where they know that aeronautical engineers have been properly recognized in the past.

By analyzing the above mentioned and other similar cases for general cause and effects some conclusions for the future may be made but we also have to assume as established facts, some basical lessons from the past.

1. That there is no force now, nor will there be in the future, which could and would order all mankind to eliminate completely from this planet the use of all aircraft for any purpose whatsoever.

2. That the ruling empires of the world, political or economical, always possessed and utilized the best available (at that time) means of transportation.

3. That technological progress will continue in the future in spite of temporary retarding forces or conditions.

4. That better technological developments will always displace previous inferior developments.

5. That in general, inventions have reached their best usefulness by detailed study, research and by development of details by specialists who actually do understand the problems involved.

6. That in modern industry, for any important work to be done, the proper men to do it are the ones who have the proper previous training for that particular work and who have keen mind to utilize that previous training to this particular work and for future developments.

A study made by S. P. E. E. in 1939–40 shows that out of a total of 103,000 engineering students in 1939–40 only 3,034 * were matriculated in aeronautical engineering, 24,000 mechanical engineering, 16,000 civil engineering and 14,000 electrical engineering or in percentages:

Aeronautical engineers were 3 per cent of the total.
Aeronautical engineers were 12 per cent of mechanical.

There are no figures available for this year's enrollment but from individual reports of largest gains in enrollment, an estimate of an average gain of 20 per cent would be very reasonable.

After the above statements some questions would be in place.

1. Is it reasonable to assume that a man whose training in his undergraduate work was directed towards the design of boiler tubes, manhole covers or auto frames is the one who should be put to design of wing ribs, gas tanks, flush wing covers or wing fittings and expect him to learn all pertaining to aircraft work after he is assigned to the job by asking questions to group leaders or through hit and miss methods?

2. Is it reasonable to believe that design, construction, maintenance and operation of aircraft and research in aeronautics will not require just as specialized undergraduate and graduate training as mechanical, civil or electrical engineering where fundamentals of science are applied to solution of specific problems in that particular industry?

3. Is it reasonable to believe that one of the following predictions wil come true:

That transoceanic travel and freight carrying by aircraft will be able to compete economically with surface vessels; or that all first class mail will go by air, train, or horse and buggy, which ever way it will get the mail there faster; or that "rule of the air" will replace "rule of the waves"; or that helicopter development will open new and popular lines of air travel.

The aeronautical board who did not register aeronautical engineers, the company which did not want to hire aeronautical engineers, the advisory board who forgot to mention aeronautical engineers, the schools who insist that aeronautical engineering work is only an option in the mechanical curriculum, all are the forces which are too slow to change and follow the progress of aeronautical engineering, but the tempo of aeronautical progress is fast and the impact is strong and those forces change after all.

* Does not include individual courses or light options in Aeronautics since the schools themselves do not consider those students as candidates for Aeronautical degrees.

At the present moment this tempo is changing so fast that neither the schools nor the industry can supply sufficient numbers of men to accomplish the tasks assigned and all kinds of substitute engineers in place of aeronautical engineers have been put to do work, a detail here and a detail there. Many a good man will come out of those substitutes who will have natural ability to adapt himself to his type of work.

But taking two men of approximately equal natural ability, one with undergraduate training in another field of engineering and one with proper undergraduate training in aeronautical engineering, there is no reason to believe that the man with aeronautical engineering training will not be a better man in preliminary design and development, aerodynamics, stress analysis, weight analysis, production, design, checking, drafting, administration, supervision and liason.

I am using a broad term when I say proper education in aeronautical engineering and I don't take any of the existing curricula as the proper one for aeronautical engineers. Just like the type of aircraft and accessories, performance and use changes, so we will have to change the curricula in our aeronautical engineering school. Many lessons will be learned in the present period, when aviation is going through the adolescent stage and is becoming an important, strong member in the technological family.

The curriculum of many schools will be changed and the time has come when no man will be able to call himself an aeronautical engineer by simply studying for a semester. Monthiet & Carter's, "Simple Aerodynamics of the Airplane," 1929 edition or equivalent. Even proper knowledge of Lamb's "Fluid Mechanics" will not make an aeronautical engineer, but the correlated application of basic scientific principles to the problems leading to better creation and operation of aircraft, shall it be practical or classical, will constitute a balanced curriculum for aeronautical engineers.

As can be seen from the papers presented by others, there is a variety of opinions of what constitutes a proper training for aeronautical engineers but if the faculties of the aeronautical schools will keep their eyes open and follow the developments and demands of the industry, proper curricula will be worked out. (I do not intend to compliment the industry and the personnel directors that they know exactly what they want.)

The 11 schools granting degrees in aeronautical engineering last year graduated approximately 400 aeronautical engineers. With the supply increased by a few new schools who might grant degrees in the next few years, and with the increase of enrollment in the schools for the next 4 or 5 years the total number of graduate aeronautical engineers will not exceed an average of approximately

500 to 600 engineers per year. If all those men would go on the drafting boards our aircraft industry would have very well trained and specialized personnel composed of aeronautical engineers exclusively. However, only 30 or 40 per cent can be expected to go on the drafting board and the rest will handle aeronautical engineering jobs in maintenance operations and research and therefore a surplus of aeronautical engineers cannot be expected, say, 5 years from now. I do think that about 6 or 7 years from now there will be a surplus of men who, without proper educational background, now are doing some work in the aeronautical industry and who will not be able to follow the new developments in aeronautical engineering.

I do see in the future a change in attitude of the employer and of the young aeronautical engineering graduate. The employer will use the young engineer, where he now is using plain draftsmen, in order to give his future senior engineer a chance for experience, and the young aeronautical engineer will be willing to start out his career by serving an apprenticeship in the shop and in the design room instead of expecting to be in charge of a project at his first assignment. This change will be natural as it was in other industries and an apprentice period will be recognized as beneficial for the employer and the employee.

ENGLISH IN ENGINEERING—IN COLLEGE AND AFTER COLLEGE*

By H. P. HAMMOND

The Pennsylvania State College

My purpose in choosing the title of this talk "English in Engineering—In College and After College" was to reëmphasize and to state anew the belief that the study of English is a process lasting a lifetime. Into it the college experience of a student must be fitted in such fashion as to play as effective a part as possible in the development of his ability to use the mother tongue and in order that the portion of his time which is devoted to English instruction may be justified.

It is a truism, perhaps, but it must be repeated here as the basis of the first portion of these remarks that we must take the engineering student when he enters college as we find him. As everyone knows, but as our instruction often doesn't properly reflect, our entering students are a pretty heterogeneous lot. As the recent Report on Aims and Scope of Engineering Education puts it, they are for the most part the *unsifted* product of the secondary schools who enter engineering study by a process of natural selection only. Little discrimination is exercised in choosing between the qualified and the unqualified. It is true, of course, that engineering students, on the whole, are the best student group, as to mental capacity and purposefulness, among those who enter college, but they are very widely diversified as to previous backgrounds and particularly as to training in English. I am sorry to say that ability and interest in oral and written expression correlate poorly with subsequent grades in science and engineering. On the whole, they bring to the study of English in college, capacities, interests, and training that are both seriously defective and seriously deficient; defective as to previous associations, and therefore in acquired habits of thought and expression (notice that I say *both* thought and expression), and deficient in quality of training, particularly as to the rigor of their previous schooling. For one thing, and perhaps of greatest significance, a great many of our entering students have never really had to learn to work. The study of

* Delivered at the 49th Annual Meeting, S. P. E. E. (English), University of Michigan, June 23–27, 1941.

English which they have previously pursued, therefore, has not taken effect, because they have not been *drilled* in the elements of expression or in the use of those elements in writing and in speech. They do not have the command of these elements which gives certainty or facility in their use.

We all know this in a general way, or at least so I judge by the vigor with which it is asserted. Perhaps I should say we are *conscious* of it; but by and large it seems to me that we do not have an adequate or accurate knowledge of just what it is that our students bring to the study of a first course in English in college. We do not have an adequate quantitative knowledge of abilities and deficiencies. A good deal is learned about this, of course, during the student's first semester, and an experienced and skillful teacher—because he *is* skillful—discerns and appreciates the background and the problems of his class early in his association with it. He then gauges his teaching accordingly. In spite of such instances, however, it seems to me that there is an opportunity and a need to appraise more accurately and more specifically the basic factor on which instruction in English in College should rest: the defects, limitations, needs, abilities, capacities, likes, dislikes, and all of the other qualities that make up the complex of a freshman class in relation to the study of a first course in English composition. In saying this I am not overlooking the fact that placement and aptitude tests of various sorts are used in a good many instances to gauge entering classes or to section them, but these tests are not nearly as searching or comprehensive as the case demands. Much more is needed, I am sure, and I am inclined to believe that a comprehensive study of this phase of your problem might be undertaken, so as to define the problem of English instruction in engineering schools more accurately in terms of the basic conditions under which it is conducted.

This, however, is more or less a digression from the main theme of these remarks. My principal purpose so far as entering students are concerned is to point out the need for the adjustment of work in English and, particularly, the first course in English composition, to the range of background and capacity of the members of the class. This has received quite a little attention and there are a good many examples of devices of various sorts to adjust the instruction to the range of capacity of the students: tutoring classes; extra hours added to the regular class schedule; sectioning on the basis of ability; noncredit courses for the very deficient; and the like.

These devices are all aimed in the right direction, of course, and the idea of adjustment of the work to the capacities of the members of the class appears to be spreading. For the most part, however,

these methods seem to be aimed at one problem almost exclusively, that of the bottom of the class. They seem to arise out of a feeling of despair of being able to do anything for this group by ordinary class methods. I would repeat that these devices are necessary and good and they should probably be used even more universally than they are at present, but I should like to take this occasion to say that an equal amount of thought and effort might be spent on the students at the top of the class—much more than is generally accorded them at present. What may be done in this direction is exemplified nicely by the plan followed by the University of New Hampshire to which I direct the attention of those who are not familiar with it. Time does not permit me to describe this in detail but I would say in brief that it exempts students from the first course in composition for whom this course is at too low a level and substitutes special assignments or readings or courses of a more advanced nature. This is accompanied by special provisions for students deficient in English who are given a rigorous drill in grammar, spelling, and punctuation before they proceed with the customary composition work.

A feature of this plan that deserves special commendation is the provision of adequate individual attention for students. This is provided through the conference method. No other device, it seems to me, is so well calculated to identify and remedy defects in English speech or writing that are difficult to get at and to cure as is the individual conference between student and teacher. It should be a part of every course in English composition and should be used with the strongest students as well as with the poorest. The New Hampshire plan therefore "takes the students as they find them" and adapts the work closely to their individual needs.

My first point, then, in this discussion of "English in College and in After Life" is that instruction, and particularly the instruction of freshmen, should be adjusted just as closely as possible to the needs and capacities of the individual students. The first step in this direction should be to find out as fully and as accurately as possible just what those needs and capacities are.

The second phase of my topic, naturally, is the place of English in the curriculum and the instruction in the use of English which students should receive in one way or another in all of their work in the school of engineering. I shall hasten through this phase by saying, first, that so far as formal instruction in English is concerned I think a reasonable and proper provision, if the customary type of course work is offered (at least it is all our crowded curricula will afford), is a 3-credit course extending through each of the first four semesters, devoted to composition, literature, and

speech. To this might be added elective offerings in English, preferably in the senior year, to complete this part of the humanistic stem of the curriculum.

In this formal class work, I am of the opinion that relatively more time and emphasis should be given to reading than is customarily the case. Perhaps this should be provided by a progressive shift from the elementary course in which attention is centered so largely—and of necessity—on writing, to the more advanced courses where writing becomes essentially a supplement to reading. I hope to develop my reasons for this presently.

You will note that I have spoken of this as the required course work. Throughout their undergraduate careers students should be encouraged by every device at our command to form the habit of reading independently of their course assignments. The teachers of English can help thus to induce students to read independently if they are adroit and do not urge the matter too obviously, but a chief source of inspiration to cultivate this habit should come also from other sources, particularly from the engineering faculty. One device that we have used with considerable success is the provision of a shelf or bookcase in our Engineering Reading Room in which is kept a small, carefully chosen changing collection of books for general reading. We have made an important point of choosing these books. They are furnished to us by the general College Library and must have clean, fresh bindings. Teachers, students, our librarian, and others offer suggestions at intervals and the Dean and the librarian together go over these suggestions periodically, take out books which are not being used, add others that are promising, and keep the shelves filled with examples of good literature. The collection includes fiction, drama, poetry, biography, travel, general science, adventure, politics, philosophy, essays—almost everything in the way of good literature. Two criteria are imposed in every selection: the book must be worth reading for its content and it must have good literary style. Most of the books are current or recent, but some, such as collections of plays and of poetry, are classics. We have now had this experiment in operation for four years and the results have been excellent. Books circulate rapidly and the total number on our list at a given time is often three or four times the capacity of the shelf. Faculty use them as well as students.

This, of course, is only one device of a number that might be used to cultivate reading habits. I believe that such devices are an important adjunct to the regular course work.

The third phase of my subject is English in the life of the engineer after graduation. I would repeat that training in the use of

English is a life process to be carried on by formal instruction in the school and college stage and by self-cultivation in the after stage. In a great many instances, perhaps in a majority, the cultivation of the taste for correct and elegant expression and for reading fine literature begins while the individual is a student when he is under some teacher from whom he acquires this taste or who ignites within him the necessary spark of interest.

I have said before on many occasions, and I repeat, that one of the chief functions of the Department of English is to direct its students along this path. I believe it ought to be planned and carried out just as systematically and purposefully as is the formal class work in the elements of writing and speaking. Perhaps the best vehicle for the attainment of this aim is work in literature, by which I mean the reading of examples of fine writing and the writing by the student in turn from these examples as his source. If this work is conducted in such a manner as to arouse the student's interest, to create in him a desire thus to broaden his horizon, to cultivate his ability, and to form a taste in expression it will accomplish a most useful purpose. What is required, of course, is sufficient provision for work of this nature in the curriculum, plus the definite formulation of the objective, plus an avowed and carefully devised policy and practice in the English department, plus a group of teachers who themselves have tastes and inclinations in this direction and therefore the necessary basis on which to interest and inspire students.

In saying all this I realize that it may sound somewhat like a counsel of perfection, but I do not think it is that. It seems to me that if as much thought and attention were devoted to this part of instruction in English as has been devoted to courses in composition as much could be accomplished in the direction I am indicating as has been done in improving the quality of instruction in the conventional courses—which, incidentally, I think has been considerable over the past few decades.

Engineers as a group are often criticized as having a narrow preoccupation with the technical aspects of their work. They are said to be unable adequately to express themselves either on general topics or, indeed, on their professional work. These criticisms should be applied, of course, with greatly differing force to various members of the profession. On the whole, however, there is some merit in the criticism. *If the condition which this criticism represents is to be remedied, more is required than can be done in the short time that the student is in college under the control and direction of a teacher of English. The faults that are to be corrected are so deeply ingrained and the tastes and abilities that are*

to be acquired are so fundamental that they can not be acquired through a relatively short period of classroom instruction. But the habit of self-education in the art of expression can and should have its beginning in college through the inspiration of the English department. Unless it is started in this way in many, many instances it will not be started at all. I repeat with all the emphasis at my command that this is both the great opportunity and the great responsibility of the instructor of English in the School of Engineering.

NEW MEMBERS

DEAN, GEORGE T., Assistant Professor of Civil Engineering, Alabama Polytechnic Institute, Auburn, Ala. T. M. Lowe, J. J. Wilmore.

EDSON, WILLIAM A., Professor of Electrical Engineering, Illinois Institute of Technology, Chicago, Ill. R. I. Sarbacher, L. E. Grinter.

FITTERER, G. R., Professor and Head, Dept. of Metallurgical Engineering, University of Pittsburgh, Pittsburgh, Pa. R. C. Gorham, F. L. Bishop.

HONOUR, WILFRED M., Assistant Professor of Civil Engineering, Alabama Polytechnic Institute, Auburn, Ala. T. M. Lowe, J. J. Wilmore.

HUDSON, PAUL K., Instructor in Electrical Engineering, University of Arkansas, Fayetteville, Ark. G. P. Stocker, F. L. Bishop.

LINDVALL, FREDERICK C., Associate Professor of Electrical and Mechanical Engineering, California Institute of Technology, Pasadena, Calif. R. W. Sorensen, Franklin Thomas.

LIVINGOOD, MARVIN D., Instructor in Chemical Engineering, Missouri School of Mines, Rolla, Mo. F. H. Conrad, W. T. Schrenk.

MIDDLETON, EWEL V., Assistant Professor of Civil Engineering, Texas Technological College, Lubbock, Texas. F. L. McRee, O. V. Adams.

MITCHELL, FRANCIS E., Instructor in Civil Engineering, University of Arkansas, Fayetteville, Ark. G. P. Stocker, F. L. Bishop.

MUNDEL, MARVIN E., Assistant Professor of General Engineering, Bradley Polytechnic Institute, Peoria, Ill. R. M. Barnes, H. O. Croft.

NEAL, HENRY P., Associate Professor of Engineering Drawing, Mississippi State College, State College, Miss. M. L. Freeman, H. C. Simrall.

NELSON, WILBUR L., Professor and Head, Depts. of Chemical and Petroleum Refinery Engineering, University of Tulsa, Tulsa, Okla. R. L. Langenheim, A. H. White.

OBERG, AARON G., Assistant Professor of Chemical Engineering, Texas Technological College, Lubbock, Texas. O. V. Adams, C. C. Perryman.

PLUMMER, CLAYTON R., Instructor in Mechanical Drawing and Machine Design, University of Tennessee, Knoxville, Tenn. R. M. Boarts, R. W. Morton.

ROBINSON, DOUGLAS I., Engineering Personnel, Sperry Gyroscope Co. Inc., Brooklyn, N. Y. H. L. Davis, C. Wandmacher.

STANLEY, CASSIUS M., Professor and Head, Dept. of Textile Engineering, Texas Technological College, Lubbock, Texas. O. V. Adams, O. A. St. Clair.

WALKER, CHARLES A., Instructor in Chemical Engineering, University of Arkansas, Fayetteville, Ark. G. P. Stocker, F. L. Bishop.

WATWOOD, VERNON B., Professor of Civil Engineering, Alabama Polytechnic Institute, Auburn, Ala. T. M. Lowe, J. J. Wilmore.

WEBSTER, FRED N., Instructor in Mechanical Engineering, Tufts College, Medford, Mass. D. A. Fisher, Edgar MacNaughton.

THE T-SQUARE PAGE

DEVOTED TO THE INTERESTS OF THE
DIVISION OF ENGINEERING DRAWING

(Second of four issues)

WILLIAM E. STREET, *Editor*,
Agricultural and Mechanical College of Texas

MODERN EQUIPMENT PLACES NEW EMPHASIS ON DESCRIPTIVE GEOMETRY

Drafting the language of the engineer in this mechanized age is necessary if an engineer is to be understood effectively. The Theory of Drafting is not sufficient unless it includes Engineering Geometry or Descriptive Geometry. Mr. A. J. Altz, Chief Draftsman, Chevrolet Division of General Motors Corporation, emphasized the need for Descriptive Geometry in his paper before The Society for the Promotion of Engineering Education at Ann Arbor, Michigan, June 23, 1941, as follows:

> "Each industry has its own peculiarities, and every company within each industry has its own individual procedure in making drawings. Therefore the most effective education in drafting for the defense industries, or for any other industry, will develop in the students a thorough understanding of fundamental drafting principles. When a graduate leaves your educational institutions, he should know and understand the principles of descriptive geometry and their application. He should understand the principles of projection so well that their application becomes automatic. He should understand the several methods of dimensioning so that he is fitted to absorb the training which industry alone can supply.
>
> "Of the dozens of technical graduates who have been interviewed for employment, the majority obviously have been misled by their instructors in college. They all come in looking for a job as an engineer. When an opportunity is offered them to enter the engineering profession by way of a well organized training program in draftsmanship, most graduates are disappointed and usually refuse the offer. They do not realize that between them and the engineering position to which they aspire lie years of training and experience which they can get only by putting their feet firmly on the first rung of the engineering ladder—drafting.
>
> "Drawing instructors play an important part in the education of young men for future engineering positions in all industries, and especially in the defense industries. They can do the greatest amount of good by imparting to their students a thorough understanding of the fundamentals of engineering drawing. Graduates should understand the principles of projection and descriptive geometry—not as rules in a text book, but by application time after time under all sorts of conditions—so they are truly *understood.*"

These applications include sheet metal drawing (Developments and Intersections), safe distances between telephone and power lines, pulley problems permitting rotation in either direction, perspective, shades and shadows, mining problems, cuts, fills, slopes of grades, circular chutes and stairways, screw threads, lofting as applied to automobiles, airplanes and ships, etc. Recent developments in air conditioning equipment, safety guards for machinery, etc. alone require a thorough understanding of the Theory of Drafting or Descriptive Geometry. Many industries today employing engineers that come in contact with Drafting or Designing will not consider a person without Descriptive Geometry.

MECHANICAL ENGINEERING PAGE

The Finest Work of Man is Building the Character of Man.

R. L. SWEIGERT, Georgia School of Technology, *Editor.*

The mechanical engineers held a conference on Mechanical Engineering Instruction at Purdue University, after the 1941 meeting of the S. P. E. E. Some of the papers will most likely be published but others will not be because of lack of space. Therefore the page will be used to acquaint everyone with the main points of the various meetings of the conference. This is made possible through the coöperation of Professor Ault, Purdue, Professor Nelson, Wisconsin, and Professor Rice, North Carolina State College.

A problem continuously facing all engineering schools is the problem of selection and promotion of its staff. Since the worth of the engineering school depends upon its faculty, it becomes necessary to establish and carry out policies of such character that the largest possible core of excellent men be maintained continuously. Dean Potter presented a paper giving some of the answers to the problem of selection and promotion of staff. The following material on the subject of selection and promotion is taken from Dean Potter's discussion. Important items to be considered in selecting a faculty member are:

1. Character. One who exaggerates, misleads, or is cowardly should be avoided.
2. Unbounded Enthusiasm. He should consider his work and specialty the best, should be interested in the student development and should not apologize for being in the teaching profession.
3. Knowledge of Subject. He should not only be a master of subject matter, but should make students want to master the subject. He must keep up with the literature in his field.
4. Optimism. He should not think conditions are getting worse, that students are becoming poorer each year.
5. Ability to talk on his feet so that he can be heard and ability to use good English.
6. Agreeableness and Patience. He should be considerate, courteous, and tactful at all times.
7. Research. He should be interested in and do some research. It might be in methods of teaching, in the preparation of books and papers, or in the laboratory.

The main function of a Dean is to keep the staff happy. Some institutions with a low salary level have a high morale; therefore a happy loyal staff is not dependent upon the salary alone. It is also part of the Dean's function to safeguard tenure. This raises the question of whether 'dead' ones should be demoted or fired. It is better in the long run to make security general even though some on the staff are ineffective. It is a poor policy to wait until a good man shops around before advancing him. This wrecks the morale of staff.

In the training of teachers, it is well for beginners to visit classes of the older men, but older ones should not visit new members' classes for the purpose of rating. School of Education techniques apply to elementary schools, not to the colleges. The time to weed out the staff is before hiring, and assistants and instructors should be hired with great care. Some gages of ability are student opinion, material on the blackboard, standing in the community. However one must beware of poor students' complaints. A one year trial period should be sufficient for judging a new man on the staff. The staff is best when it is made up of representatives from various institutions. Local graduates on the staff are desirable but the percentage should not be too large. For promotions and heads, men should be appointed from the staff. A liberal policy is needed in connection with outside work as this helps improve a faculty member, but it should not be overdone to the detriment of school work. Some overdo on outside work in performing ordinary testing rather than in doing a beneficial type of work.

COOPERATION FOR VICTORY *

SCHOOLS that have industrial equipment and facilities for training are expected to make more intimate and accurate contacts than they have made at any time in the past with the important industries in their immediate or surrounding localities. This is essential if they are to play their appropriate part in training the manpower that an AMERICA AT WAR is now demanding.

The President's program of war equipment and munition production enormously increases the responsibility of schools to make the fullest contribution in their power. Every school and all instructors who are doing any work in the direction of craft, vocational or technical training are definitely requested to render NEW help in the government's WAR PRODUCTION PROGRAM.

This help may be given three ways:

(*A*) Training of NEW workers with as much speed and to as high a degree of accuracy as possible—in many cases altering existing training so as to transfer non-essential skills to specific required skills of a related nature.

(*B*) The STEPPING-UP of the less experienced and potentially skilled people—boys, girls, men and women—into stations where they can serve within the shortest time the nation's imperative war production need. This must be done largely through evening or other part-time intensive short-unit courses.

(*C*) By coöperation between schools and school instructors on the one hand and the employers on the other, whether done with the aid of school equipment or within industry's plants, or whether done through the professional skill of the educator or through the experience and technical skill of the industrialist.

For any of these three ways time is TOO SHORT for the usual kind of vocational training now in general use to be really effective.

WHAT IS REQUIRED is that the worker be made immediately useful as a unit of increased output in a shop. Hence, what he needs is practice on those specific skills which develop in him as he works on items of production or important subdivisions of items of production.

In order to conduct work of this essential character teachers and schools are expected to secure the coöperation of the appropriate key men within the industries; and to obtain from them recommendations that will fit the above requirements in a training program.

As the processes and problems of industry are changing so rapidly —with new conditions arising every few weeks and in some instances every day—the schools and school instructors must keep most frequent and accurate contacts with the industries in and about their communities.

IN CONCLUSION, industries which make THE BEST USE OF SCHOOLS and schools which MEET FULLY THEIR RESPONSIBILITY OF TRAINING WORKERS will best meet the PRESIDENT'S CHALLENGE. COMPLETE COOPERATION and UNDERSTANDING of the MUTUAL AID that war industries and the schools of their community can give is a best FIRST STEP toward VICTORY.

February 11, 1942.

* REQUESTED OF SCHOOLS BY THE TRAINING WITHIN INDUSTRY BRANCH of the LABOR DIVISION of the WAR PRODUCTION BOARD.

OUR ANNUAL MEETING WILL BE DEVOTED TO WAR PROBLEMS

By ALFRED H. WHITE

President

Our annual meeting will be held in New York City on Saturday, Sunday and Monday, June 27–29, 1942, and will be devoted entirely to serious study of the important problems now faced by our colleges. Social features and inspection trips will be eliminated.

Any doubts as to the attitude of our members were dispelled by the answers to the questionnaires returned by deans of engineering colleges and members of the Council of our Society. Replies were received from 116 deans. Most of them regretted that attendance would be smaller than usual because their staffs would be teaching in the summer term, but two-thirds of the deans believed the meetings should be held anyway and only four, out of all the engineering schools located within 1,500 miles of New York City, reported that they could not have any representative at the convention.

Final decision as to the general features of the program was reached at a conference of your officers with the deans of the twelve colleges in the metropolitan area who had invited us to hold our meetings in New York City. Our hosts were reluctant to abandon the social events and the trips which they had hoped to offer to their guests, but agreed that, on this occasion, the whole time should be devoted to work.

The meetings were shifted to a week-end to permit members to attend without loss of too much time from classes. The program will consist of authoritative reports from governmental agencies in Washington, and of discussions of the accelerated programs and other measures which we are taking to meet the emergency. General sessions will be held on Saturday morning, Sunday morning and afternoon, and a very informal dinner Sunday evening. Conferences will be held Saturday afternoon and evening with conference dinners held Saturday night. On Monday there will be conference meetings at several colleges in the New York area so that our members can see for themselves how these schools are handling their problems.

The whole program will focus on our war efforts. The change to a week-end convention will permit a much larger attendance. Those who come are certain to be well repaid for the effort.

NEW PLANS FOR ANNUAL MEETING

Announcement of Plans for Gearing Our June Meeting into the National War Effort

REVISED DATES: JUNE 27–28, 1942

By HAROLD E. WALTER *

Since the first broaching of plans for the Society's Fiftieth Annual Meeting this June, and the mapping out of all the social and recreational activities with which the technical sessions were to be surrounded, much has happened both on the anti-fascist fronts abroad and in the increase of responsibilities by our members at home. In the light of these events, many of our members have been asking themselves two important questions: whether in such a time we are justified in planning an Annual Meeting at all; and if so, what sort of Meeting we must have to justify the expenditure of valuable time and funds.

It was in order to answer these two questions that members of the Society's National Committee came East last month to confer with the deans and presidents of the twelve institutions who jointly extended to the Society the invitation to hold the Meeting this year in New York. After considering all phases of the situation, including the opinions on the matter of all institutional members of the Society, the National Committee and the Convention Committee decided that a conference in war-time to consider problems of engineering education is far from being a needless luxury, but is even more important than in ordinary times. Every day the papers bring home to us the real need the nation has for young men soundly trained in engineering; and every day as we become more and more involved in accelerated programs, new requirements, special courses and special demands on our facilities for training, we realize how much we are in need of a complete investigation of the subject and a thorough talking over of our rôle in the national war program.

The Committee therefore has decided that the gearing of engineering education groups into the national war effort should be

* Professor Walter, Dept. of Mechanical Engineering, Newark College of Engineering, is Chairman of Publicity on the Local Committee for Arrangements for the Society's Annual Meeting in New York, June 27–29, 1942.

done by every means at the Society's disposal, among which is the Annual Meeting. Streamlining the Annual Meeting to a really efficient weapon in the war effort has been done by cutting its length to two days and scheduling it for a weekend (June 27th–28th) in order that as many as possible of the Society's members may attend. Into the two days will be crowded all the technical sessions we can hold in the time—there will be three general sessions as well as time for conference meetings. These sessions will be built around key men in the war effort, whose information on how the engineering colleges can best serve the nation will be so important to our members that few should afford to miss it. All trips, excursions and social events will be cut out, with the exception of the traditional Annual Banquet. Even the Banquet, however, will be in keeping with the economy-efficiency note of the Meeting, and is being transformed into an informal Annual Dinner.

Previously we were looking forward with much satisfaction to offering the Society as wide and varied forms of entertainment and as interesting trips and excursions outside the sessions as have been given to the members during former Annual Meetings in other localities. But great events mean drastic curtailment of any "business-as-usual" activity; the Local Committee in charge of arrangements has willingly shifted its plans, and is now bending all its attention toward making the local accommodations comfortable and convenient for the members who will gather both in and out of the regular sessions to discuss the important problems of today's engineering necessities.

The Women's Program has of course been curtailed along with all other "unnecessary" expenses. No formal program for members' wives who may come to the Meeting is being planned, therefore. However, a good attendance of the ladies is one of the traditional attributes of a successful S. P. E. E. Meeting, and we hope that we will not be left entirely without such companionship. Women who do attend the Meeting will be more than welcome at all technical sessions; they will find moreover a warm welcome and as many impromptu good times as can be arranged over the weekend by our very enthusiastic and efficient Women's Committee which, despite the slashing of its program for such excellent reasons, is still anxious to have at least a few wives to entertain.

The National Committee, the twelve host institutions, and the local committees making arrangements for the Fiftieth Annual Meeting are proud to offer to the members of the Society a Meeting so in keeping with present exigencies and duties as the one we are planning. The loss of the usual pleasant social attributes of the Annual Meeting is more than compensated by the fact that

no arrangements in connection with the Meeting can possibly be labelled "frills and furbelows"; the loss of the Meeting as a "vacation" opportunity seems inconsiderable when we consider the increase this year of the importance of its function as a guidepost to the responsibilities and duties of its members in the field of engineering education. The part which engineering is playing in modern warfare need not be emphasized here; the conspicuous need for teachers of engineering to become correctly related to the war program is obvious. This Meeting will provide the Society with unparalleled opportunities for service to its country and to the institutions that employ its members. These institutions, in turn, can contribute much by seeing to it that one or more of their representatives is present at this particular Meeting.

The general arrangements of the Meeting will be covered in the May issue of the JOURNAL. The National Committee will soon forward to members a preliminary program and schedule of the meetings, together with pre-registration and room reservation forms. Accommodations will be provided from Friday evening, June 26th, through Sunday evening, June 28th. We urge you to return these forms as quickly as possible, and we trust that they will give us a basis for really expecting a large and enthusiastic attendance.

In accordance with our previous articles on the Annual Meeting, we are providing a description of four more of our host institutions. Each of them extends a hearty invitation to you to visit them while in this area.

NEW YORK UNIVERSITY

BY EDWARD F. McDOUGAL

One of the largest universities in the world, New York University was founded in 1831, and is a privately endowed, non-sectarian institution maintaining branches of instruction throughout the city —from Wall Street in the heart of the financial area, to the beautiful fifty acre campus at University Heights. Its fifteen schools, colleges, and divisions offer programs in nearly every field of higher education, including liberal arts, fine arts, commerce, public service, engineering, law, medicine, dentistry, education, and retailing. The sub-divisions of these general topics occupy the time and energies of a faculty exceeding 2,000 men and women.

The College of Engineering, which shares the uptown campus with the College of Arts and Pure Science, is housed in five buildings, and has a faculty of 200 men, headed by Dean Thorndike

Saville. It has an enrollment of some 1,000 full-time day students, 1,200 evening students, and 366 graduate students in its departments of administrative, aeronautical, chemical, civil, electrical, and mechanical engineering, and department of meteorology. In addition, during the present national emergency, some 1,400 men have already been trained under the Office of Education defense training program, and a like number are currently enrolled for this type of instruction.

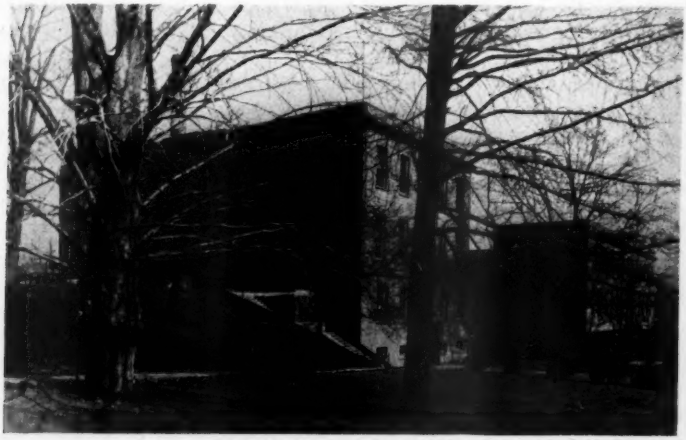
Of special interest to engineers visiting New York City are the facilities of the College in the fields of sanitary engineering, aeronautics, meteorology, and ordnance. In coöperation with the City of New York there has been erected on the campus an unusually large and well-equipped Sanitary Engineering Research Laboratory, which is unsurpassed as a center for the study of chemical, bacteriological, and other public health research problems. Here, in addition to graduate and undergraduate instruction, work is carried out for private, city, state, and federal agencies.

The work in aeronautical engineering is conducted in the Guggenheim School of Aeronautics, endowed by the late Daniel Guggenheim. This branch of the College is housed in its own building, and among its features are two wind tunnels, where many of the nation's aircraft were first put to scientific test. One of the tunnels is capable of producing a flow for tests up to 90 miles per hour, while the other is used for testing up to 50 miles per hour. The former is being redesigned so that shortly its capacity will be increased for tests at 130 miles per hour. The tunnels, instrument laboratory, materials testing equipment, and other apparatus are constantly engaged, not only in student instruction and independent research, but also in research of a coöperative nature with the leading aeronautical firms in the East.

In the realm of meteorology the College has established a completely equipped weather station, where all of the apparatus necessary for the conducting of a forecast center is available. A direct line teletype, affiliated with the weather bureau network makes complete the "data collecting" devices that makes possible the issuance of a daily forecast for circulation throughout the university. Some 60 graduate students from Federal agencies are now receiving instruction here.

The Gage Laboratory was established by the Ordnance Department of the Army and is the only one of its kind in the East. It is used for graduate instruction, for research in precision instruments, for checking of precision parts by the Ordnance Department, and for the training of Reserve Officers. It is presently the center of important activities concerned with defense production.

Also a part of the campus at University Heights is the Hall of Fame for Great Americans, an impressive colonnade overlooking the Palisades, which has become in every sense of the word—a national shrine.



Sage Building and Guggenheim School of Aeronautics, New York University.

NEWARK COLLEGE OF ENGINEERING

By R. W. VAN HOUTEN

The Newark College of Engineering, instituted in 1919, is a development of the Newark Technical School founded in 1881 by the Board of Trade of Newark. The College is a public institution supported by both the City and the State and is governed by a Board of Trustees appointed by the Governor of the State of New Jersey. The Governor and the Mayor of Newark are ex-officio members.

The control and supervision of finances of the College is vested in the Board of Regents of the State of New Jersey.

The College is situated in the heart of Newark at High Street and Summit Place. The work of the institution is carried on in four buildings. The recitation halls are adequately equipped modern structures, particularly suited to requirements of an engineering college. Completely equipped laboratories in the fields of chemistry, chemical engineering, physical chemistry, electricity, mechanical engineering, metallographic and heat treatment, physics, soil mechanics, and strength of materials are also included in these buildings.

When Dr. Allan R. Cullimore came to Newark in January, 1920, to head the new college, there was a student body of only 40, the first class having entered the previous September. Today 1,090 students are registered for college work. Of this number 120 are

Gate and Administration Building, Newark College of Engineering.

taking graduate courses which are being given under a coöperative arrangement with the Stevens Institute of Technology.

In 1936, Dr. Edward Weston bequeathed to the College his scientific library of approximately 12,000 bound volumes and 65,000

periodical issues together with his collection of scientific and laboratory apparatus of historic interest. Arrangements are now nearing completion for providing adequate facilities to make these collections available to the students and the public. Anyone attending the S. P. E. E. convention will be welcome to visit the Weston Museum and view the apparatus on display.

Visitors to the convention who are interested in the field of Management will enjoy visiting the Frank B. Gilbreth Room in which will be found some of Mr. Gilbreth's original equipment together with many photographs and charts of historic as well as current significance.

The Newark College of Engineering's outstanding contribution to engineering education has been in the field of human relations. It was to a college committed to the coöperative plan that President Cullimore came in 1920. He saw, even at that time, that there was a need for men who were not only trained engineers in the technical sense, but who also were acquainted with the personnel problems of industry. Therefore, the coöperative plan at Newark, as it has been developed, has become not primarily a medium for giving an undergraduate a chance to acquire certain manual skills, but rather an opportunity for him to become personally acquainted with the diverse human problems of industry. The work given in industry under the supervision of the College during the summers following the sophomore and junior years is limited, however, to those men who have shown maturity, accomplishment, and development in the first two years of their college work.

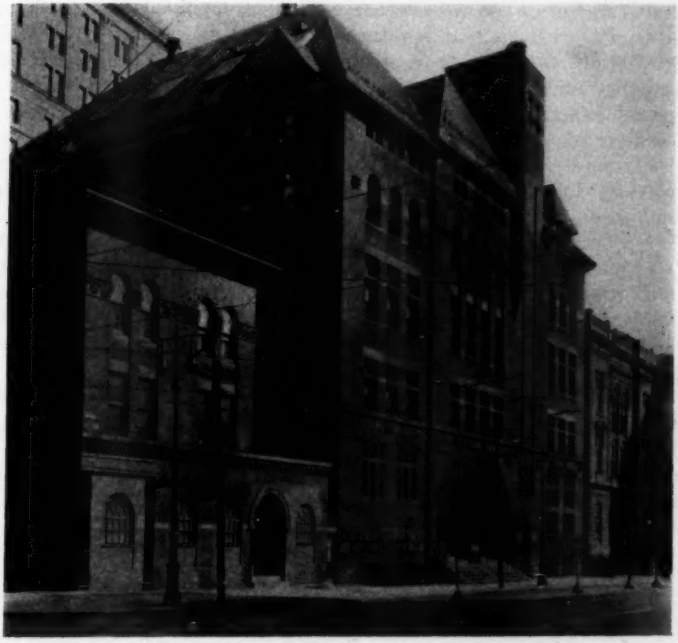
POLYTECHNIC INSTITUTE OF BROOKLYN

By ERICH HAUSMANN

Polytechnic Institute of Brooklyn is a privately endowed college of engineering and science located in downtown Brooklyn adjacent to the Borough Hall. It began as an academic and collegiate school at its present location in 1854 and the work in Arts was continued until 1908. Engineering courses were introduced at an early date and the first engineering degrees were awarded in 1871. The present instructional program covers curricula in aeronautical, chemical, civil, electrical, mechanical and metallurgical engineering, and in chemistry and physical science, all leading to baccalaureate degrees with designation of the major department of study.

A notable contribution to professional education was made by Polytechnic about forty years ago through the introduction of evening courses, parallel in scope, comprehensiveness and standards with those of the day session and leading to like degrees. These courses afford employed technical and scientific workers the oppor-

tunity to improve their professional training, to broaden their cultural horizons through evening study, and to earn degrees that are recognized by all appropriate accrediting agencies. While these courses are given in large part by the resident staff, certain of them over the years have been conducted by distinguished engineers and specialists from industrial laboratories, public utilities and consulting firms.



Institute and Administration Buildings, Polytechnic Institute of Brooklyn.

Programs of study leading to the master's degree were introduced in the Day Session in 1904 and in the Evening Session about twenty years later. Master's curricula are now available in the fields of chemical, civil, electrical, and mechanical engineering, and in chemistry and physics. Further extensions were made in advanced instruction by establishing doctoral programs in chemical and electrical engineering and in chemistry, and by coördinating a series of fundamental courses into a comprehensive group to emphasize the broader and more general principles of the engineering

sciences. Polytechnic was a pioneer in the development of evening graduate courses and the phenomenal growth of such offerings in the New York Area was reported upon at the last Annual Meeting of the Society.

Stress has always been placed upon the investigational aspect of learning by requiring a thesis project as part of the requirements for both baccalaureate and advanced degrees. This independent work on the part of the student is coördinated with the researches of staff members and in many cases receives financial support from industrial concerns and institutional grants. In recent years the publications resulting from such investigations have been collected annually and reprinted for distribution to interested groups. Special experimental facilities are available in most of the engineering and scientific laboratories for basic research, especially in aerodynamics, viscosity studies, shellac investigations, distillation processes, highway materials, electrical measurements, microwaves, combustion, metallography, and spectroscopy.

Polytechnic has over 700 students enrolled in its 4-year day curricula leading to baccalaureate degrees and over 2,300 evening undergraduates; most of the latter are pursuing standard 8-year degree programs. There are over 650 graduate students taking individual courses or carrying on programs for advanced degrees, one-fifth of them already possessing the master's degree.

The teaching staff comprises a faculty of over 60 in professorial grades and an associated group of about 200 instructors and part-time lecturers. The institution is managed by a Corporation of twenty members and its educational and investigational work is directed by President Harry S. Rogers.

PRATT INSTITUTE'S SCHOOL OF SCIENCE AND TECHNOLOGY

By FRED H. GERTZ

Pratt Institute was founded and endowed in 1887 by Charles Pratt, a practical and successful manufacturer who was deeply interested in education. It was his aim to found a school whose courses should be so conducted as to give every student definite, practical skill along some one line of work and at the same time reveal to him the possibilities for development, service and culture inherent in all work.

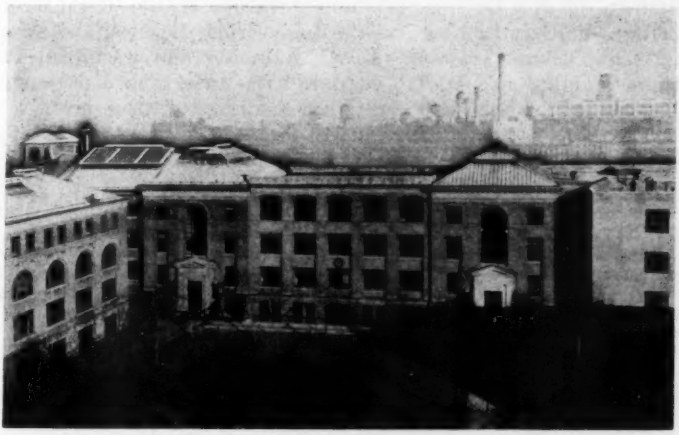
The other schools of the Institute are: the Art School, the School of Home Economics, and the Library School.

The charter was granted by the Legislature of the State of New York on May 19, 1887, and the Institute opened its first classes in

October 1887 with twelve students. In 1940–41 the enrollment in day and evening classes was over five thousand. Since the founding of the Institute the total enrollment has been 222,234.

The School of Science and Technology of Pratt Institute celebrates its fiftieth anniversary in 1942, having begun operation five years after the founding of the Institute.

The School had its beginnings in the Institute's Department of Mechanic Arts. Continued expansion of this department led to the creation, in 1892, of the School of Science and Technology. From 1892 to 1934 two-year curricula were offered, beginning with Industrial Mechanical Engineering in 1892, Industrial Electrical



Science and Technology Group, Pratt Institute.

Engineering in 1896, and Industrial Chemical Engineering in 1905. To meet the increasing demands of industry these curricula were expanded to three year courses in 1933.

In 1934 the School initiated its four-year engineering courses as now conducted. The three day courses, Mechanical, Electrical, and Chemical Engineering are each a four-year degree course so arranged that the first three years provide a well integrated engineering and technical education and lead to the granting of the Institute's Certificate. The student who has met the School's requirements may elect to continue study in his curriculum for another year. Upon completion of this fourth year he receives the bachelor's degree in the branch of engineering he had selected. For the school year 1940–41 the day school enrollment was 542.

The School's non-collegiate, evening technical school is unique in the New York metropolitan area. The wide variety of courses offered is intended to meet the needs of the man in industry who wishes to improve his technical and engineering knowledge. Over one hundred, twelve-week, single-subject units are offered; in addition definite programs of these subjects have been formulated, leading to an Evening School Certificate in a wide range of subjects. The 1940–41 enrollment in the evening school was 1,866.

A full-time faculty of 47 is augmented by 47 part-time evening school instructors.

Participating in the Defense Program, the School provides instruction in both shop practice and physics of engineering to all students of the Defense Training Institute of the Engineering Colleges of Greater New York. Engineering, Science, and Management Defense Training (E. S. M. D. T.) and vocational Defense Training (V. D. T.) courses, both under the direction of members of the School's faculty, are conducted at the school.

Delegates to the conference will be most welcome to visit the School's well equipped shops and laboratories during their stay.

In connection with the article "New York Invites You," printed in the March issue of the JOURNAL, credit was not given to the individuals who provided the material relating to the four host institutions described. The coordinator of the material for the JOURNAL, Professor Harold E. Walter of the Newark College of Engineering, regrets this oversight, and wishes to make acknowledgment as follows for the provision of these articles:

College of the City of New York: Mr. Irving Rosenthal, Director of Publicity.

Columbia University: Office of Public Information, Mr. James T. Grady, Director.

Cooper Union: Mr. Edgar L. Jones, Department of Public Relations.

Manhattan College: Professor Louis Backer, Department of Physics.

FORECASTING THE ACADEMIC ACHIEVEMENT OF ENGINEERING STUDENTS *

By CORNELIUS H. SIEMENS

University of California

Probably no question holds as prominent a place in the minds of the students and is of as much concern to the engineering departments as that of success or failure in classroom work. Many students worry over the questions:

> Should I continue engineering as a career?
> Am I making good enough grades to be reasonably successful, first as a student and later as an engineer?

At the same time the administration seeks to answer such questions as:

> Should this student be encouraged to continue or be advised to choose some other major?
> Should this probationary case be carried for another semester or are the chances of success so small as to justify dismissal?

At present, satisfactory means have not been developed whereby such problems can be solved with dispatch and with a high degree of reliability. However, a great deal can be done to produce answers which are something more than mere opinion or guesswork. The high mortality among engineering students alone demands that more reliable and helpful techniques be developed and employed in advising students as to their probable success. The trial-and-fail method is altogether too costly in time and energy for student and institution alike.

The results of a recent study indicate that a solution of the problem is not impossible. The records of 1400 students in the four engineering departments at the University of California were studied to ascertain how well upper division engineering success could be forecast. The grade-point average (G. P. A.) in all upper division courses was chosen as the criterion of engineering academic success, inasmuch as it is only with the junior year that most students have a program made up entirely of engineering courses. Furthermore, it is only after the student undertakes upper division

* Presented at the meeting of the Pacific Southwest Section, Fresno State College, December 29, 1941.

work that a serious loss of time would result should he be forced to drop out because of scholarship.

The study proposed to answer the following questions:

1. What factors in the record of a student best predict upper division success and how efficiently do they operate?
2. How well can the best combination of factors forecast upper division academic success?
3. With what reliability and how effectively can forecasts be made for the junior college transfer student?

To indicate how well a factor might forecast the upper division G.P.A. the zero-order correlation coefficient between the factor and

TABLE I

BEST FACTORS FOR PREDICTING UPPER DIVISION SCHOLARSHIP (X_0)

Factors	Native Group[a] N = 583		Transfer Group[b] N = 243	
	Correlation Coefficient	Probable Error	Correlation Coefficient	Probable Error
G.P.A. of the first semester of upper division engineering (X_1)—8 units or more	.87	.01	.87	.02
G.P.A. of all lower division work (X_2)—about 64 units	.70	.01	.67	.02
G.P.A. of college mathematics (X_3)—12 units or more	.69	.02	.60	.03
G.P.A. of college physics (X_4)—12 units or more	.69	.02	.60	.03
G.P.A. of college chemistry (X_5)—10 units.	.61	.02	.50	.04

[a] Those students who completed all of their college work on one campus.

[b] Those students who completed all of their lower division work at one junior college and then transferred.

the success criterion was calculated. Knowing the coefficient, a prediction of the criterion from the factor can easily be made. A number of factors from the high school, junior college, and university records of achievement were examined. Table I lists the factors that proved to be best for forecasting the G. P. A. in upper division engineering. The correlation coefficients and their probable errors are also given to show the extent of the relationship between each factor and upper division scholarship.

The standard formula to use for making a forecast of upper division engineering ($\bar{X}_0$) from, say, the G. P. A. in mathematics (X_3) is

$$\bar{X}_0 = r_{03}\frac{\sigma_{X_0}}{\sigma_{X_3}}(X_3 - M_{X_3}) + M_{X_0}.$$

The constants σ (standard deviation of G. P. A.) and M (mean of all G. P. A.) were determined for each group and department, leaving r_{03} and X_3 as the variables that determine the predicted criterion $\bar{X}_0$. Reliable predictions cannot be expected by using only one factor. However, it was found that a fairly good forecast is possible if a number of separate factors are used and then their average taken as the composite prediction.

It was found possible to develop a single equation using all of the factors at one time in such a way that the best prediction the factors are susceptible of giving is obtained. Briefly, the method to develop the equations is an application of the Tolley-Ezekial method* of handling multiple correlation problems. The process involves the means and standard deviations of each group as well as all possible correlations and intercorrelations. This resulted in a linear equation of the following form:

$$\bar{X}_0 = K_1X_1 + K_2X_2 + K_3X_3 + K_4X_4 + K_5X_5 + K_6X_6 + C,$$

in which the K's and C are constants determined for each group. Although the G. P. A. of high school science and mathematics work (X_6) by itself was discovered to have negligible value as a predictor ($r = .35 \pm .06$), it proved to be of value when added to the equation combining all six factors.

It was found advisable to develop the following five equations for each group:

1. An equation to forecast the upper division G. P. A. using the six factors X_1–X_6. This equation was designed for application only upon the completion of one semester of upper division work.
2. An equation to forecast the upper division G. P. A. using the five factors X_1–X_5. The omission of X_6 was necessary because in some cases the high school record is unavailable.
3. An equation to forecast the upper division G. P. A. using the factors X_2–X_6. This equation was designed for application at the end of the lower division work; hence factor X_1 was omitted.
4. An equation to forecast the first semester of upper division work using factors X_2–X_6. It was designed for application at the end of the lower division work. The result was used to check the predicted score with the actual achievement after only one semester of upper division work.
5. An equation to forecast the first semester of upper division work using the four factors X_2–X_5. The failure of some records to include the high school work made this equation necessary.

* See Tolley, H. R. and Ezekial, M. J. B. "A Method of Handling Multiple Correlation Problems," *Journal of the American Statistical Association* Vol. 18: 993–1003 (Dec., 1923).

Once the grade-point averages of the several factors had been calculated from the record, it was not difficult or time-consuming to calculate the predicted G. P. A. from the equation.

The question now remains, Do the equations predict well enough to merit their use? To test the validity of the equations, predictions ($\bar{X}_0$) for 200 unselected cases were made and the results compared with the actual upper division grade-point average (X_0). It was found that the chances were even that a predicted score would not vary from the actual by a more than .20 of a grade-point unit. This represents one-fifth of the distance between, say, a C and a B grade. For instance, if the forecasted score is 1.60, the chances are even that the actual G. P. A. can be expected to lie in the range, 1.40 to 1.80. Furthermore, the differences between each predicted and actual score were tabulated. The average of all the differences ($\bar{X}_0 - X_0$), neglecting the algebraic sign, was .26. Of the 200 test cases, 54 per cent had a positive difference, whereas the average algebraic difference was .034. In correlating the actual and predicted scores, the coefficient was found to be $.89 \pm .01$, and the theoretical multiple correlation R was calculated to be .88.

Hence the equations seem to prove out in practice just as well, if not better, as the theoretical statistical characteristics of the equations indicate and the errors of prediction are small enough to warrant the extensive use of the forecasting equations.

Contrary to the belief held by many, the junior college transfers not only did as good work in the upper division engineering courses as the other students, but it was found that forecasting upper division success upon the basis of their junior college record could be done as effectively as it could for native students. In the case of the smaller junior college transfer group (less than thirty-five), however, forecasting errors were found to be large. In the main, the study showed that it is possible to forecast engineering success efficiently for junior college transfers at the time of their transfer.

The following applications of the prediction equations are suggested to improve and extend the guidance work of engineering departments and colleges sending students to them:

1. The guidance of junior college students before they transfer might be improved by indicating to them and advising them concerning their probable success in upper division work.
2. Engineering departments to which transfers come could determine early the potential success of transfers and counsel them accordingly.
3. The predictions could be used as a part of a technique for determining the admission of students to upper division status in engineering.

4. An index of probable success could be given to every student at the end of both his second and third years of work. This procedure has been found to stimulate the better students. Also, on the basis of such information, some students might transfer to other departments (or schools) early enough to avoid the loss of time and money. Those students who prove to be working above expectation deserve to be commended, while those whose performance falls below prediction should be called in for advice and counsel.

The officers of the Michigan State College Branch of the Society are: O. W. Fairbanks, Chairman; C. A. Miller, Vice-Chairman; L. S. Foltz, Secretary; J. E. Robertson, Treasurer.

There are fifteen members of the teaching staff of the engineering division who have been active in the creation of the Chapter. E. E. Kinney is Chairman of the Program Committee. We are indebted to you and to the Secretaries of many Chapters of S. P. E. E. for assistance during the last several years and hope that the future may justify our long travail.

ACTIVITIES OF THE CIVIL ENGINEERING DIVISION S. P. E. E. 1940–41

By LORENZ G. STRAUB

University of Minnesota, Past Chairman, Civil Engineering Division

The Ann Arbor meeting, of course, was the dominating feature in the activities of the Civil Engineering Division during the past year. There have been, however, several other focal points of activity in which the Division has participated—these largely through sections, the identity of which are established by standing committees. In the following report there is given a brief resume of the sessions at the Ann Arbor meeting and also of some of the other activities of the Civil Engineering Division. The Civil Engineering Bulletin, which has now been published for six years, was continued during the past year under the editorship of Frank W. Stubbs, Jr., Rhode Island State College. The members of the standing committees of the past year were published in Volume VI, No. 1, December, 1940, pages 10 and 11.

Ann Arbor Meeting

The Ann Arbor program of the Civil Engineering Division had as its central feature a general session including a Symposium on Teaching Methods, which extended over the morning and afternoon of the first day of the conferences. This symposium was sponsored by Committee I—Educational Policy and Teaching Methods—of which J. E. Buchanan, University of Idaho, was chairman. The other seven standing committees of the Civil Engineering Division coöperated in this general session and also arranged for special conferences and programs of their respective committees.

The programs of the regular standing committees were held as special sessions on Tuesday afternoon and Wednesday afternoon. The chairman of each committee, assisted by eight committee members, arranged the sectional conferences and programs. The committee chairmen in charge were as follows: Committee II—Structural Engineering—M. S. Ketchum, Case School of Applied Science; Committee III—Sanitary Engineering—W. E. Stanley, Cornell University; Committee IV—Transportation—E. T. Howson, Editor, Railway Age, Chicago; Committee V—Applied Hydraulics—N. A. Christensen, Colorado State College; Committee VI—Construction

Education—H. E. Pulver, University of Wisconsin; Committee VII—Foundations and Soil Mechanics—John D. Watson, Duke University; Committee VIII—Surveying and Geodesy—G. H. Harding, University of Louisville.

In addition to the sectional programs there were several additional features, which were handled by special committees of the Division. The program for the annual dinner of the Division was arranged under the chairmanship of R. H. Sherlock, University of Michigan. Still another dinner meeting and evening conference, under the theme Civilian Protection in War Time, was arranged by a special committee under the chairmanship of H. E. Wessman, New York University. Lorenz G. Straub, University of Minnesota, was general chairman.

The committees of the past year involved about a hundred members in the Civil Engineering Division. There were about forty-five prepared papers and discussions presented at the Ann Arbor meeting at the sessions of the Civil Engineering Division. Arrangements have been made to have some of these published in technical journals outside of the Society. Others, in so far as space permits, will be published or given in resume in the Journal of the Society or in the Bulletin of the Civil Engineering Division.

Teaching Methods.—The Symposium on Teaching Methods, which was so arranged to avoid conflicts with any other sessions of the Division, was presided over in the morning by Committee Chairman J. E. Buchanan, and in the afternoon by S. T. Carpenter, Swarthmore College. The various standing committees were represented by the following speakers on teaching methods: Structural Engineering by Frank Kerekes, Iowa State College; Sanitary Engineering by W. C. Hoad, University of Michigan; Soil Mechanics by P. C. Rutledge, Purdue University; Construction by H. E. Pulver, University of Wisconsin; Applied Hydraulics by W. M. Lansford, University of Illinois. These formal talks were followed by discussions from the floor.

Civilian Protection in War Time.—There was an informal luncheon meeting the first day, and a dinner meeting that evening. The program following the evening meeting provided one of the most timely and interesting sessions of the conference, for which much credit is due Harold E. Wessman, New York University. The general topic of the symposium was Civilian Protection in War Time. W. A. Rose, New York University, presided. The principal speakers and their subjects were: Walter D. Binger, New York City, The Civil Engineer's Responsibility in the Work of the National Technological Civil Protection Committee Appointed by the Secretary of War; Charles B. Breed, Massachusetts Institute

of Technology, New Transportation Problems Associated with Civil Defense; Major E. W. Ridings, Washington, D. C., The War Department and Civilian Protection. Discussion was opened by M. S. Ketchum, Jr., Case School of Applied Science, on the topic Problems Facing Local Engineers on Civilian Defense Committees. The speakers on this program were all closely associated with national civil defense activities: Mr. Binger as Commissioner of Borough Works of Manhattan and Chairman of the National Technological Civil Protection Committee; Professor Breed as a member of the National Committee on Civilian Protection in War Time of the American Society of Civil Engineers; and Major Ridings as a United States Army Officer assigned to the Office of Civilian Defense in Washington, D. C.

On Tuesday afternoon there were three conferences running simultaneously along the lines of standing committees, namely, Structural Engineering, Sanitary Engineering, and Transportation. On Wednesday afternoon the conferences of the Division were divided into four groups: Applied Hydraulics, Construction Education, Foundations and Soil Mechanics, and Surveying and Geodesy.

Structural Engineering.—At the conference on Structural Engineering M. S. Ketchum, Case School of Applied Science, presided, and also presented the committee report. The papers on the program related to the advisability of a building construction option in the curriculum for civil engineers, by W. A. Rose, New York University; the use of models in structural engineering, by L. C. Maugh, University of Michigan; and the use of structural models for bending moments, by W. J. Eney, Lehigh University. The program of the Structural Engineering conference was followed by an inspection of laboratories of the Departments of Civil and Engineering Mechanics of the University of Michigan.

Sanitary Engineering.—The conference on Sanitary Engineering was presided over by T. M. Lowe, Alabama Polytechnic Institute. Chairman W. E. Stanley, Cornell University, sent the committee report in writing, being unable to attend. A spirited discussion followed presentation of the formal papers. The principal speakers were H. E. Babbit, University of Illinois, on sanitary engineering teaching and the defense program; G. E. Symons, Buffalo, N. Y., on the teaching of sanitary engineering as related to water and sewage works operation; and Arthur B. Morrill, City of Detroit, on vocational guidance and sanitary engineering instruction.

Transportation.—The theme of the conference on Transportation was Preparing to Meet Transportation's Demands in a Streamlined Age. Committee Chairman E. T. Howson, Western Editor

Railway Age, presented his report through John S. Worley, University of Michigan, who presided. Other papers on the program were by J. H. Cooper, Superintendent, Ft. Wayne Division, Pennsylvania Railroad, on Pointing the Graduate Towards Success in Railroading, and Professor Worley on Revision of Courses of Instruction to Meet the Conditions of 1941.

Applied Hydraulics.—A conference on Applied Hydraulics was held with Committee Chairman N. A. Christensen, Colorado State College, presiding. R. L. Daugherty, California Institute of Technology, discussed objectives of the first course in hydraulics or fluid mechanics. A paper on development of undergraduate fluid mechanics was presented by J. W. Howe, University of Iowa, with the aid of lantern slides to explain a unique series of experiments which have been developed at the University of Iowa in contrast to the usual experiments in hydraulics. A third illustrated paper was presented by R. C. Binder, Purdue University, on the role of fluid machines and devices in connection with fluid mechanics instruction. Discussion followed, some of which was a reverberation of the chronic argument on hydraulics versus fluid mechanics. Following the meeting R. A. Dodge, University of Michigan, exhibited his unique and interesting apparatus for demonstrating fluid mechanics principles.

Construction Education.—A varied and interesting program was sponsored by the committee on Construction Education under the chairmanship of H. E. Pulver, University of Wisconsin, who presided at the meeting. A. J. Ackerman, Director of Engineering of Dravo Corporation, gave an interesting illustrated talk on "Construction Planning and Plant." Other stimulating talks were given by G. C. Tomlinson, Senior Office Engineer of Tennessee Valley Authority, on "Construction Education Needed by Civil Engineering Students" and by R. H. Sherlock, University of Michigan, who gave a progress report on employment of civil engineers in the construction industry. The committee on Construction Education sponsored the preparation of a comprehensive survey and report on content of courses in construction, which was prepared under the chairmanship of M. I. Evinger, University of Nebraska.

Soil Mechanics.—The program set up by Chairman John D. Watson, Duke University, on Foundations and Soil Mechanics was in charge of W. S. Housel, University of Michigan, who presented a paper on the measurement and application of soil properties in engineering design, followed by demonstrations in the soils laboratory at the University of Michigan. Two further papers were on soil mechanics studies for the Chicago subway, by Ralph Peck,

Soils Engineer of the Department of Subways and Traction of Chicago, and on the progress in soil mechanics research, by Don Taylor, Massachusetts Institute of Technology.

A conference on Surveying and Geodesy was held Wednesday afternoon under the auspices of the Surveying Committee.

Special Meetings.—An especially delightful annual dinner meeting of the Civil Engineering Division was arranged for Wednesday evening by a local committee. R. H. Sherlock, University of Michigan, presided. Entertainment in lighter vein was furnished by the Rodeo Boys of the Ford Motor Company, a Welcome by Dean Ivan C. Crawford, University of Michigan, and Response by L. G. Straub, University of Minnesota, was followed by an illustrated address on the historical background of the University of Michigan by L. M. Gram, Chairman of the Civil Engineering Department at the University.

A conference Wednesday morning on Defense Training in Civil Engineering was addressed by Arthur S. Adams, Cornell University, on an evaluation of the influence of the national defense program upon the civil engineering profession. Dean Ivan C. Crawford, talked on the civil engineering defense training program at the University of Michigan, and F. M. Dawson, University of Iowa, outlined some special defense training courses being given in civil engineering at that University.

The officers and directors elected at the business session of the Division, to hold office for the current year, are as follows: Chairman, J. S. Dodds (1943), Iowa State College; Secretary, E. E. Bauer (1942), University of Illinois; Editor, H. E. Davis (1943), University of California; Directors, L. G. Straub (1942), Past Chairman, University of Minnesota; L. S. LeTellier (1944), The Citadel; C. A. Mockmore (1944), Oregon State College. The retiring members of the executive committee are: M. W. Furr, Kansas State College, and F. W. Stubbs, Jr., Rhode Island State College.

Other highly successful conferences sponsored by the Civil Engineering Division in coöperation with other organizations were held during the past year. These include the following: National Congress on Surveying and Mapping held in Washington, D. C., June 16–18; Hydrology Conference at Penn State College, June 30 to July 3; and Aircraft Structures Conference at New York University, September 5–6, 1941.

National Congress on Surveying and Mapping

The National Congress on Surveying and Mapping was sponsored by the Civil Engineering Division Committee on Surveying and Geodesy in coöperation with the following other organizations:

Surveying and Mapping Division, American Society of Civil Engineers; American Society of Photogrammetry; Federal Board of Surveys and Maps; and National Geographic Society. Major G. H. Harding, Chairman of the Committee on Surveying and Geodesy served as chairman of the Committee on Arrangements for the Congress, and as Congress chairman until the election of officers took place.

Annual meetings of the Congress are proposed. In the permanent organization the United States was divided into ten regions with a vice-president elected for each region.

There were 163 persons in attendance at the Congress. The following summary is quoted from the record of the proceedings of the Congress:

In the last several decades at least 17 studies have been made for the purpose of better coördinating, surveying, and mapping activities, Robert H. Randall pointed out to the Congress. Notwithstanding these efforts, 29 federal agencies, receiving annual appropriations exceeding $20,000,000, maintain diverse and uncoördinated systems of obtaining, recording, and processing survey and map data. It was emphasized that numerous duplicating surveys for different purposes were made by the various federal, state, county, and local organizations. Coördination of efforts would prevent much of this unnecessary duplication of surveys and maps, and would provide better maps for all purposes.

Marshall S. Wright of the U. S. Department of Agriculture discussed the teaching of photogrammetry and aerial surveys in engineering schools. Mr. Wright stated photogrammetry represented the greatest single contribution to surveying and mapping in over two centuries. The Department of Agriculture has made aerial surveys of over 90 per cent of the nation's agriculture lands. Increased employment of the aerial method of surveying was recommended.

The need for more and better publicity for maps and map-making was emphasized by Commander K. T. Adams of the U. S. Coast and Geodetic Survey. He stressed also the desirability of making larger scale and more accurate maps and contrasted the completeness and quality of maps in European countries with those prepared in this country.

Various types of surveys and surveying and mapping were discussed from the floor by persons from all parts of the United States. Outstandingly evident was the frequent reference to the need and desirability of local and private surveyors to tie-in with the state coördinate system and surveys of high order of accuracy. The discussion disclosed that more publicity should be given to the availability of specific maps and control data and that their widespread use should be encouraged.

The survey and mapping work being done in Cleveland was detailed by Brooks Earnest of the Case School of Applied Science.

George D. Whitmore of the Tennessee Valley Authority in discussing county surveys and property maps stated that the preparations of complete property maps disclose many properties heretofore unknown to the

tax assessor. He suggested that the cost of such maps would soon be amortized through increased revenues.

The surveying and mapping work conducted through the assistance of the Work Projects Administration was clearly explained by Murray Y. Poling. He stressed especially the lack of information on city surveys and the need for the promotion of long range planning of surveying and mapping programs to adequately meet future needs. Accurate and convenient controls on basic surveys are essential as otherwise these are likely not to be used to tie-in usual surveys. Another point Mr. Poling brought out was the wide variation in scales, accuracy, symbols, etc., of maps and the need for standardization.

The problems of surveying and mapping for civilian defense and military purposes were discussed by Lt.-Col. R. M. Herrington, Major H. B. Loper, Major W. F. Barck and Capt. A. J. Sweet, all of the Corps of Engineers, U. S. Army, and W. N. Brown, Surveying and Mapping Division of the American Society of Civil Engineers. All agreed that the most important consideration is the availability of maps when needed for military purposes. Most maps used for military purposes are furnished by other agencies or are prepared from information obtained from these agencies. The military authorities are now making maps from aerial photographs, with both vertical and horizontal controls established, though these have been found to be difficult to tie-in to common controls. W. P. A. projects have been set up in the nine Corps areas for collecting from various sources, collating, and mapping data for the entire country. The projects also color process the maps in suitable forms for all War Department uses. The War Department plans call for the conversion of geodetic controls now on various data and in far too many forms of record to a common denominator. Mr. Brown stated that aerial mosaics from the agricultural agencies, state coördinate controls from the U. S. Coast and Geodetic Survey, and detailed topographical surveys are being used for locating military establishments and defense industry sites.

The use of aerial photography in making topographic maps was discussed by E. T. Pendleton of the U. S. Coast and Geodetic Survey. He outlined the progress that has been made in the use of stereoscopic methods in elevation work.

Wider use of the statewide plane coördinate system was advocated by Philip Kissam of Princeton University. Also urged was the establishment of central state survey agencies to clear, coördinate, and preserve survey and mapping information.

At the conclusion of the technical sessions of the Congress resolutions were adopted providing for the following actions:

1. Endorsing the early completion of the basic topographic survey and mapping of the United States.

2. Evidencing a deep interest in surveying and mapping and urging close coöperation in facilitating and expediting adequate mapping throughout the American continent.

3. Advocating the use of the plane coördinate system as bases for

recording surveys and preparing maps and recommending legislative approval for description of land boundaries.

4. Recommending the use of control stations made by federal, state and county agencies as bases for local surveys.

5. Approving the creation of state and local agencies to serve as clearing houses and archives for surveying and mapping information.

6. Providing for coöperation with the American Society of Civil Engineers and other organizations in all activities and matters concerned with surveying and mapping.

7. Recognizing surveying and mapping as a major branch of engineering and seeking to have engineering schools and organizations regard these in the same light.

Hydrology Conference at Penn State

The Hydrology Conference, which was held at State College, Pennsylvania, immediately following the meeting at Ann Arbor, was highly successful. Much credit is due F. T. Mavis, Pennsylvania State College, who was general chairman. In addition to the Civil Engineering Division of the Society the sponsors included: The Section of Hydrology of the American Geophysical Union, The Committee on Hydrology of the American Society of Civil Engineers, and the Pennsylvania State College.

Engineers and hydrologists from 31 states including the Canal Zone and the District of Columbia attended. A total of 230 were registered at the meetings. Fifty hydraulic engineers and hydrologists representing government agencies, corporate and private enterprise took part in the scheduled program.

The conference included five major symposia covering a broad field of hydrology, and several round table discussions. The headings of the symposia were as follows: 1. The Scope of Applied Hydrology; 2. Rainfall and Runoff; 3. Delays in the Hydrologic Cycle; 4. Losses in the Hydrologic Cycle; and 5. Flood Problems. The proceedings of the conference are to be published.

At the principal dinner meeting of the conference Dr. Daniel W. Mead, Madison, Wisconsin, was presented a scroll honoring him as "Civil Engineer, Teacher, Leader in Applied Hydraulics, Pioneer Hydrologist, Honored Guest of the Hydrology Conference."

Aircraft Structures Conference at New York University

The Aircraft Structures Conference held at New York University September 5–6, 1941, was a phase of the activities of the Committee on Structural Engineering of the past year under the

chairmanship of M. S. Ketchum, Case School of Applied Science. Local chairman was W. A. Rose, New York University. Coöperation was given by the S. P. E. E. Committee on Aeronautics, and the Engineering College of New York University. The primary purpose of the conference was to orient structural engineering teachers in the field of aircraft structures. It proved to be an especially successful and stimulating meeting. Papers were presented by both teachers and engineers in the practice of aircraft structures. There follows a resume of the meeting prepared by Chairman M. S. Ketchum.

On the morning of Friday, September 5, F. K. Teichmann of New York University discussed The History and Development of Aircraft Structures. This paper showed the trend of airplane construction from tubular framework to shell construction. In a paper Codes and Specifications for Aircraft Structural Design by Burdell L. Springer of the Civil Aeronautics Administration, the requirements of the government for aircraft structures were presented.

At noon on Friday, a luncheon was held at the Commons of New York University presided over by H. E. Wessman of New York University. The speaker was Hardy Cross of Yale University who clearly defined some of the policies that the teaching profession should take in training structural engineers for aircraft design.

In the afternoon, the sessions were devoted to more technical problems. A most interesting paper was Details for Aircraft Construction—Materials and Methods presented by Guy A. Luburg of the Brewster Aeronautical Corporation, Long Island City, New York. Educational problems were discussed in Course Content for Aircraft Structures by N. S. Hoff of Polytechnic Institute of Brooklyn. The application of methods of aircraft structural analysis to other problems was given in a paper Application of Aircraft Structural Theory to Civil Engineering Structures by M. S. Ketchum of Case School of Applied Science. A study of the background of aircraft design was presented in Aerodynamic Bases of Structural Analysis by Alexander Klemin of New York University.

On Saturday morning a most interesting and instructive talk was given on Methods for the Analysis and Design of Shell-Type Structures by Lieut.-Commander Joseph A. Wise, U. S. Naval Academy. The final paper of the session was given by Oscar Erlandsen on The Place of Indeterminate Structures in Aircraft Structural Analysis. Mr. Erlandsen particularly emphasized the complexity of some of the problems and the importance of studying the deflections of aircraft structures. The group was particularly impressed by the amount of time available for the analysis of structural details and the precision with which the failure of some of the parts of an airplane could be predicted.

A COURSE ON EXPERIMENTAL STRESS ANALYSIS

By JOSEPH MARIN

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Introduction—Course Objectives

For a number of years the importance of experimental methods of stress analysis has been realized. These methods have been very useful as auxiliary tools in both machine and structural design. An experimental procedure for stress calculations is valuable since, in some engineering problems, a theoretical analysis is impractical or impossible. In some applications, furthermore, the approximations made in the theoretical analysis make it highly desirable to have available an experimental check on the stress calculations.

The well-known method of photoelasticity has been the most useful experimental procedure for stress analysis. The importance of this method is indicated by the large number of photoelastic laboratories in both industrial organizations and educational institutions. Many other experimental methods for solving specific problems have been devised but they are not as common as the photoelastic method. A number of universities offer courses in both photoelasticity and structural models. In the field of structural models the pioneer work of the late Professor Beggs of Princeton, Professor Wilbur of M. I. T. and Professor Eney of Lehigh should be mentioned. Instructional development work on photoelasticity has been done by many, including Frocht of Carnegie Tech., Mindlin of Columbia, Murray of M. I. T., and Wiebel of the University of California.

The object of this paper is to outline a new course on Experimental Stress Analysis which covers a number of subjects in addition to photoelasticity and structural models. The course was given by the writer both as a senior elective and a graduate course the past two years at the Illinois Institute of Technology. A special laboratory was developed for this purpose. With the exception of the optical photoelastic equipment, most of the equipment can be easily built in a college machine shop.

One of the main objectives of this course is to present the basic theory upon which the various experimental methods of stress analysis are based. Experiments on specific problems are then performed and, in most cases, values determined by theory are

compared with the test results to emphasize the discrepancies or the agreement between these values. Laboratory technique is reduced to a minimum, thereby making it possible to cover a larger number of the different types of experimental methods.

Outline of Lectures

The subject matter covered by the lectures in this course is indicated by the following chapter headings of the mimeographed notes used for this subject:

Part A—Elementary Theory of Elasticity

Chapter I—General Equations for Two-dimensional Stress Problems.
Chapter II—Applications.

Part B—General Experimental Methods of Stress Analysis.

Chapter III—Photoelasticity.
Chapter IV—Strain-Rosette Method.

Part C—Special Experimental Methods

Chapter V—Membrane Analogy Method.
Chapter VI—Mechanical Methods of Obtaining Influence Lines.
Chapter VII—Miscellaneous Methods.

Part A deals with a brief development of the two-dimensional theory of elasticity. The fundamental equations are derived and sufficient theory is given to obtain stress values in specific engineering problems. With this as a basis, the limitations of the theory of elasticity are realized so that the importance of experimental methods of stress analysis is appreciated.

In *Part B*, two general experimental methods of stress analysis are discussed—the photoelastic and strain-rosette methods. The theoretical basis for these methods is presented in detail as well as the experimental procedures and applications of the methods.

The remaining chapters in *Part C* deal with special procedures, such as the membrane analogy method for determining torsional stresses in members of noncircular cross section, and the mechanical method of obtaining influence lines to study effects of moving loads on structures. Finally, a number of other experimental techniques and analogies, as, for example, the electrical and hydro-dynamical stress analogies are discussed briefly.

Outline and Description of Experiments

An attempt is made to correlate, as far as possible, the lecture and laboratory work. For this purpose a number of experiments

are made at the beginning of the course in which measurements of strains and deflections are made on beams and other types of members. The theory for the stresses and deformations in these members is already known by the student from his work in strength of materials. These simple experiments are then followed by tests demonstrating principles developed in each chapter on theory. A list of the tests usually considered in the course follows:

1. Stresses and deflections in statically determinate and indeterminate beams.
2. Verification of Maxwell's law and principle of superposition.
3. Deflections of frames loaded in plane of frame and perpendicular to plane of frame.
4. Measurement of moments in frames by the moment indicator.
5. Determination of shear center in a structural section.
6. Determination of Poisson's ratio.
7. Photoelastic determination of stresses in a machine or structural member.
8. Determination of stresses in a circular plate by the strain-rosette method.
9. Determination of torsional stresses in members of noncircular cross section by the membrane analogy method.
10. Determination of influence lines by the Beggs and Eney deformeters.

Experiments 1 to 5 illustrate the experimental deformation method of stress analysis. In these tests, measurements of strains or deflections are made on models of beams and frames. Both statically determinate and indeterminate problems are considered and the theoretical values of stresses and deflections are obtained. The energy method for determining deflections in structural frames is used. The experimental values of stresses and deflections are then compared with the theoretical results.

In experiment 1, stresses and deflections are measured in a cantilever beam, a simply supported beam, and two statically indeterminate beams—one a continuous beam and the second fixed at one end and simply supported at the other (Fig. 1). The experimental value of the bending stress is found by measuring the strain on the outer fiber using a Huggenberger Tensometer. The deflections at various points are measured by means of dials. The theoretical and experimental values of stresses and deflections are compared, and in this way the student obtains an estimate of the accuracy of the theory used. Tests on beams are described in more detail by Everett.[1]

In experiment 2 the beam tester shown in Fig. 1 is used. This test verifies experimentally two important principles used in structural analysis; namely, Maxwell's law of reciprocal displacements, and the principle of superposition. This test can be made for both deflections and stresses.

Experiment 3 determines load-deflection diagrams for models of frames loaded both in the plane of the frame and at right angles to the plane. By considering both these types of frames, axial, bending and torsional stresses are developed. Frames which are

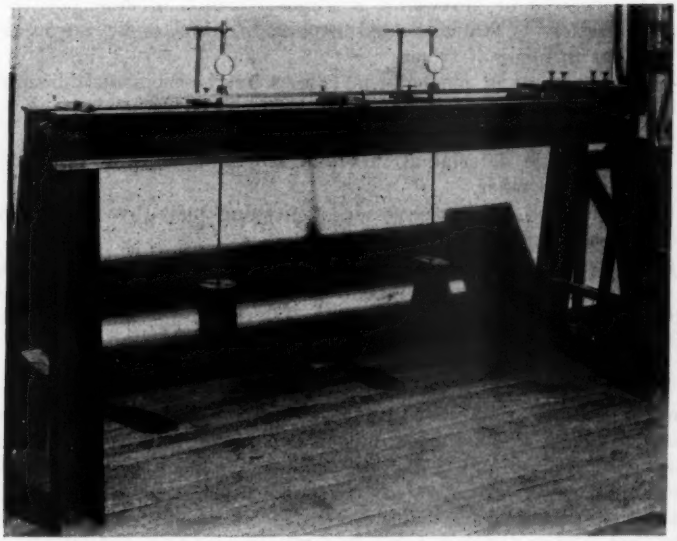

FIG. 1. Apparatus for the study of stresses and deflections in beams.

statically determinate and indeterminate are considered and the experimental values of deflections are compared with the theoretical values.

Experiment 4 gives another deformation method of analysis. In this test, the moment indicator is used for determining moments in models of frames (Fig. 2). This method was developed by A. C. Ruge and E. O. Schmidt [2] and measures the lateral deformation at two points on a member of a loaded frame. From these deflection measurements the relation between the bending moments at the ends of the member can be obtained. With additional deflection measurements on the other members of the frame the moments at all

points can be evaluated. This is a useful experimental method for complicated statically indeterminate structures. The lateral deflections are measured by means of micrometer microscopes shown in Fig. 2. The values of the moments obtained by deflection measurements on celluloid models of frames are compared with the theoretical values.

Experiment 5 on the shear center of a structural section is a special problem which can best be considered as a demonstration test. The shear center for a channel section is obtained by applying loads at different points in a plane at right angles to the longitudinal axis of the beam. Deflections at the ends of a cross-bar provide a

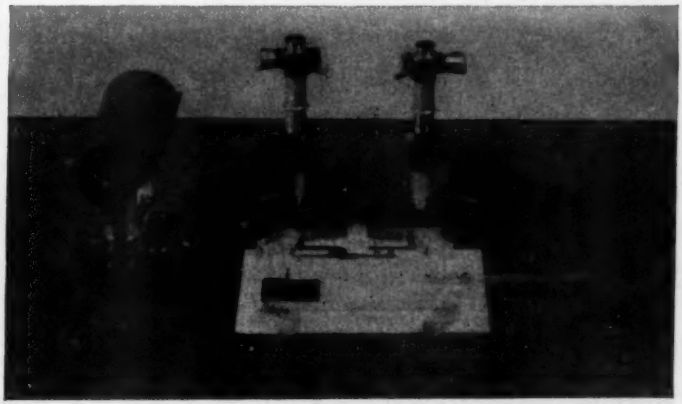

FIG. 2. Equipment for determining moments in frames by the moment indicator.

means of determining the angle of twist, and, by interpolation of the data, the location of the load for zero angle of twist is located. This point is the shear center. The experimental value is then compared with the theoretical value.[3]

The determination of Poisson's ratio is made in experiment 6. The test is made by subjecting a beam to pure bending free from transverse shear stresses. This method has been used for many years. Poisson's ratio becomes equal to the lateral curvature of the beam divided by the curvature in the plane of the load and longitudinal axis of the beam. These curvatures are obtained by measuring the deflections for a selected gage length of the beam. Although this is not an experiment on stress analysis it is included since Poisson's ratio is used in advanced mechanics of materials and it is an experimental constant seldom determined.

The work on photoelasticity (experiment 7) covers at least four laboratory periods. Each student group selects a particular machine or structural member to analyze, and at least one laboratory period is devoted to polishing, machining, annealing, and the general preparation of the model and a tension calibration specimen. With polished and annealed Bakelite, BT-61-893, available, the time for preparation of specimens is reduced to a minimum. Details of laboratory technique and theory for the photoelastic method are treated in many publications. For instructional use, the recent book by M. M. Frocht should be mentioned.[4] The second laboratory period on photoelasticity is devoted to necessary adjustments of the optical system and the determination of the stress fringe value by

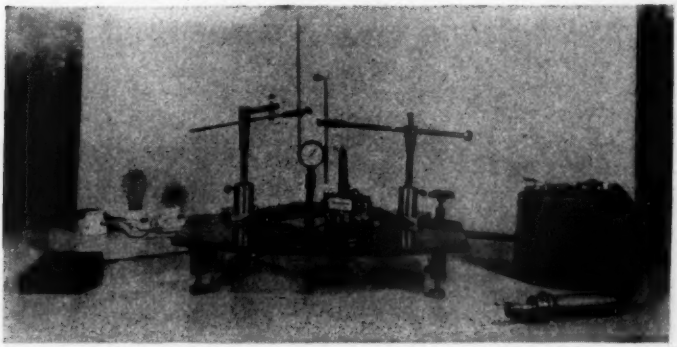

FIG. 3. The strain-rosette method applied to a plate subjected to a uniform load and clamped at the edge.

means of the pure tension calibration specimen. The third laboratory period is used to determine the boundary stresses at particular points in the model. The values of the stresses at these points are determined from measurements of loads acting and number of fringes produced at the point. These stresses are then compared, where possible, with the usual theoretical calculations. Other laboratory periods are sometimes devoted to the taking and developing of stress fringe photographs, the determination of stress directions (isoclinics), and the exploration of stress values at some points inside the boundary of the model.

The *strain-rosette method* has become an important general method for studying two-dimensional stresses in complicated machine and structural parts (experiment 8). By this procedure the strains are measured in three directions at the point considered and from these measurements the principal stresses at the point can be

determined.[5] To explain this method a circular plate clamped at the edge and subjected to an internal pressure is used, as shown in Fig. 3. Strains are measured with a Huggenberger tensometer of ½″ gage length at several points on the plate. The principal stresses for these strain rosettes are computed based on the strain readings. A comparison is then made between these stresses and the values computed by theory. The deflections of the plate are also measured to indicate an additional comparison between the theoretical and experimental values.

The remaining experiments (9 and 10) have application only to special problems. One of these is the *Membrane Analogy* procedure

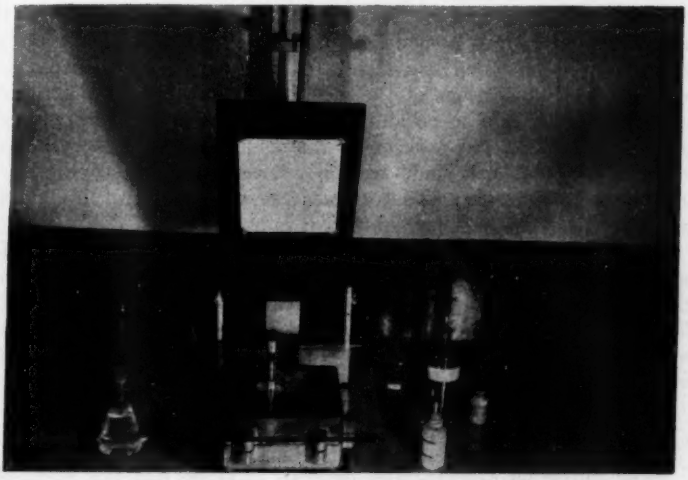

FIG. 4. Membrane analogy apparatus for determining torsional stresses.

(experiment 9) for determining torsional stresses in members of various cross sections. The apparatus used for this test is shown in Fig. 4. In this method the cross section of the torsional member is cut out of an aluminum plate to some convenient scale. A circular section is also cut out of the plate to be used later for purposes of calibration. This plate is then clamped between two castings, as shown in Fig. 4, and a soap film of special composition is stretched over the two openings. An air pressure is applied to the film and a micrometer—attached to the glass plate shown—is used to determine the shapes of the surfaces of the two films. It can be shown that the differential equation for the film surface is similar to the dif-

ferential equation for the torsion stress problem, and that slopes on the film are proportional to shear stresses.[6] Various types of cross sections may be studied, such as channels and angles for which no exact theory is available.

Another special experimental method of stress analysis that is of interest only to the student in structural engineering is the *mechanical method for finding influence lines* in structural models (experiment 10). An influence line represents the variation in a stress function for a particular section or member of a structure, produced by a unit load moving across the structure. It is used for stress calculations in such structures as bridges. These influence lines can be determined analytically but in some problems considerable time is saved by finding them experimentally. In the mechanical procedure a model, usually made of celluloid, is constructed to a convenient scale and, by measuring certain displacements at specific sections of the model, influence lines for various stress functions can be obtained—the influence line being represented by the deflected position of the model.[7] The measurements of the deflections are made with a micrometer microscope when using the *Beggs Deformeter Apparatus*, or with a magnifying glass when the *Eney Deformeter equipment* is used.

There are a number of other special experimental methods of stress analysis which have been used and which might be added to the above for purposes of demonstration. Such procedures are, for example, the electrical analogies for finding torsional stresses in members of varying circular cross section, and the electrical method for finding stresses in models of bridge trusses.

Conclusion

The course on experimental methods of stress analysis outlined in this paper is an attempt to offer a more general course on experimental methods than the work on photoelasticity given at many engineering schools or in courses on structural models offered in structural engineering curricula.

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TAKING THE CREAM OFF ENGINEERING

By W. B. PIETENPOL

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The title of this paper, which may seem to imply that physics is taking the cream off engineering, was in a sense forced upon me. The responsibility perhaps rests with Professor Grantham of Cornell University who, in an article entitled "A Subject Matter Inventory,"* cites certain statements of teachers of engineering subjects. In his words these teachers have asked "why the teacher of elementary physics cannot 'stick' to his physics instead of 'taking the cream off' their subject before the student reaches them."

If my title implies that I am supporting the thesis that physics is taking the cream off engineering let me clear my position at once. To me such an implication is as ridiculous as the opinion once expressed to me by the head of a mathematics department. He maintained that physicists should not introduce students to some of the basic principles of the calculus—the idea of a derivative or integration as an inverse process—for it took away from the calculus the interesting part of the course.

That physics is fundamental to and intimately related to engineering may be accepted without question. May I quote a Biblical statement, "If the salt have lost its savour wherewith shall it be salted?" The following query may not be Biblical but you may agree with me that it is pertinent. When engineering has lost its appreciation of physics as an energizing force wherewith shall it justify its very existence? One needs only to go back historically to the origins of physics as a science and to the amplifications that have been introduced in order to obtain a proper insight into the relationship of this science to engineering. Physics came into being partly because of the need for laws and principles that would be useful in the arts and crafts of early times. Out of need the being grew. Man sought to satisfy his curiosity concerning nature's ways and to extend his ingenuity to the building of a civilization. Our child grew until it could no longer be housed in a single structure. So wide and varied became this body of knowledge that a need arose for specialists in the various fields to carry on work of a developmental nature and to apply the fundamental principles

* G. E. Grantham, Am. J. Phys. 9, 52 (1941).

of physics to industry. So, with physics as a basis, we have the various fields of engineering, each specialized field usually launched by the physicist, and each field making its own wonderful contribution to progress. The engineer and the physicist have worked hand in hand, the physicist leading in new fundamental discoveries and the engineering applying and extending this knowledge to human needs and industrial developments and in turn suggesting new avenues of research for the physicist. I need not tell you this but I do think it highly important that the physics teacher impress upon his students early in their engineering training the importance of physics in their academic careers. May I ask how can one fairly "stick" to physics without giving his engineering students a taste of the cream. To use a different analogy, it is like laying a postage stamp on a letter without applying the moisture of correlation and expecting the message to reach its proper destination.

Most readers will agree with me in the assertion that, in teaching engineering students, we must stress the importance of the application of the science to the engineering profession. The important question that arises is how can this best be accomplished. Let us consider the matter briefly from two points of view; the writing of textbooks and scientific articles; and verbal presentation to students. Some of my remarks with regard to textbooks, doubtless will apply to verbal discussion as well.

In textbooks and articles great care should be taken with regard to accuracy of statement and correct scientific approach. Before the cream rises let us be careful not to contaminate the milk. You may say that goes without question and indeed it should. Nevertheless, one could easily cite numerous instances of the misuse of terms. For example, if I say that, owing to the attraction of the earth, my body exerts a pressure of 155 lb. on the floor of a room, it will be only out of the kindness of your heart if you agree with me. My point of course is that, in teaching engineering students, we are introducing them to physical concepts they will use throughout their careers, and they should leave the course with ideas that are fundamentally correct. We may give them some of the cream of the curriculum but in the very act we should not invite future indigestion.

Then there is the important matter of the right approach. One may wonder why an author will launch into elasticity or hydrostatics letting the students use the concept of force as a push or pull, instead of introducing them to the dynamical concept of force; or why he will define simple harmonic motion in terms of the circle of reference, instead of introducing the idea from the laws of elasticity, particularly since then the projection of uniform circular

motion so readily follows. The right approach is very important in teaching physics, for physics is a logical science. Much can be done to lessen a student's dread of derivations if, first of all, known relationships are stressed and then the problem is analyzed from the point of view of logical development. The student is frequently surprised that a complicated formula often may be easily obtained with the help of simple mathematics. The training in analysis and deduction is all important for engineers, for they should be trained to meet problems that are not worked out in books.

My second point in this cream-and-content question is intimately related to the long textbook problem or the subject matter inventory. We may well keep in mind that in teaching engineering students the thing of primary importance is to give them a thorough drill in fundamental principles. But this cannot be done in an interesting way or even well if everything else is excluded. In the first place in our engineering colleges we are not teaching our youth to be merely mechanics. They as well as other students should know more than their own generation. Professor Grantham states that "physicists are proud of the contributions of their science to the developments of our civilization" and that "this pride has caused the textbook author and teacher to cling to the story of discovery." The implication seems to be that in his opinion this should not be done. While I am not advocating the inclusion of a history of physics in a textbook I do think that a proper emphasis should be given to the historical picture. I like to emphasize the fact that future historians may not speak primarily in terms of the rise and fall of kings, of the growth and decline of political parties, or the winning of wars, but rather in terms of the impact of the discoveries in physics and engineering upon the world order. Physicists can help much to give the engineering student a proper insight into the origin of his field and in doing so we are not taking the cream off but we are putting cream on engineering.

Much can be said for the omission of detailed and involved descriptions of engineering devices and "especially the meaningless photographs that accompany such descriptions." I agree with this but not to the extent of simply "brief statements mentioning the application of a principle to a machine." Here we must strike a happy medium. Discussions of applications should be concise but sufficiently clear to impress the student with the fact that the principles involved will be of value to him later on in his work. Aside from striking lecture-demonstration experiments, many engineering students find the study of physics to be drudgery. These students fail to realize the need of a thorough training in fundamental physical principles, the amplification of which is engineering. They

think only of the practical aspects, perhaps being ambitious to build railroads or operate industrial plants. Frequently they cannot understand why they should be able to derive a formula when the engineering handbooks list all the formulas with explicit directions for their use. This attitude constitutes a problem for the textbook writer as well as for the teacher.

Let us now consider the proposal of Professor Grantham that a more complete discussion of contemporary physics be given. In this connection one may question the meaning of "contemporary physics." He goes on to state "it does not add to the enthusiasm of the student for the author to state in the preface of his textbook that only physics preceding the twentieth century is to be discussed." This may have been intended as a facetious remark, for the obvious retort is that the physics we can give beginners in a single course was almost as good at the beginning of the twentieth century as it is today. This statement of course does not apply to the applications which I have advocated. I would indeed emphasize the application of fundamental principles to recent devices, for example, the radio tube, the photoelectric cell and the x-ray tube. But to advocate the inclusion of contemporary physics if that means fission, as suggested, is in my opinion practically suggesting that all of our physical knowledge may be condensed in a single book. This does not mean that we should rule out all reference to new discoveries, in particular, such things as the comparatively recent atomic particles. This material should be woven into the text as occasion demands, but in a beginning engineering course no adequate survey of atomic physics is possible. Some things must be left for future consideration.

Thus when the author of an elementary textbook for engineers feels that the success of his endeavor depends upon the amount of material he includes, he is working under a misapprehension. We as physics teachers have a better background than is furnished by the subject matter of a given elementary textbook. When time permits—and if the course is conducted properly there will be time—then in our discussions we may sojourn into wider fields to stimulate interest and emphasize to the student the wide scope of the subject; introduce new discoveries, new applications of physical principles to engineering development in a concise way and without too much detail, mention recent research; yes, even one's own research for there is nothing that in a better way will command of the students a high respect and proper response. If I were to write a rule for good teaching of physics for beginning engineering students it would be worded something like this: emphasize fundamental concepts and principles; give much attention to how these

principles find applications in engineering, and then, in addition, stimulate an interest in the science as it is related to world progress.

Is physics taking the cream off engineering subjects? My answer is emphatically in the negative. Engineering is too rich in all of its constituents to be appreciably centrifugated by a beginning physics course. Our task is to give the students a foundation on which to build a superstructure, a basic training so that they may understand and appreciate engineering subjects that follow. If this can be accomplished then our task is well done.

BOOK REVIEW

Higher Mathematics for Engineers and Physicists. By Ivan S. Sokolnikoff and Elizabeth S. Sokolnikoff. Second Edition. 587 pages. Price, $4.50. McGraw Hill Book Company, Inc., 1941.

In "Higher Mathematics for Engineers and Physicists" the authors have presented a textbook that fills a very real gap between calculus and the applied sciences.

The authors have divided the text material into 12 chapters, each of which is as near as is possible an independent subject, for instance chapter 7, "Ordinary Differential Equations," constitutes a very good course in Elementary Differential Equations. Chapter 1, "Infinite Series," is a very thorough treatment of the various expansions in series. Chapter 2, "Fourier Series," along with chapter 8, "Partial Differential Equations," is a very complete discussion of Fourier Series and boundary value problems. Some of the other more important chapters are "Solution of Equations," "Line Integral," "Vector Analysis" and "Complex Variable." All are quite complete.

The authors do not hesitate to go back to fundamentals in the derivations, thus avoiding the mistake that many authors make in "It may be shown" methods of derivation that are so commonly used and about which so many Engineers complain.

There are over 500 well-chosen problems which are well distributed throughout the text; answers are at the end of the book.

This book is very well suited as a reference book as well as a text for graduate study of Engineers and Physicists.

P. E. Rush.

WICKENDEN'S "THE SECOND MILE"

I

By CHAS. F. SCOTT, Chairman, E. C. P. D. Committee on Professional Recognition

"What is the Engineering Profession?" was the apt rechristening of the address as condensed in *Mechanical Engineering*.

Everett S. Lee, vice president of A. I. E. E. and chairman of the E. C. P. D. Committee on Professional Training, expresses these "Thoughts on The Second Mile":

> Would that every engineer would read and study the address on "The Second Mile" delivered by Dr. William E. Wickenden, President of Case School of Applied Science, before the Engineering Institute of Canada, February 7, 1941. As George Stetson, Editor of *Mechanical Engineering*, has so well said in the April issue, "we ought to pluck Dr. Wickenden out of his many duties and send him around the country to carry this message to all engineers," and for our benefit he has printed a liberal portion of the address on pages 297–299. Every engineer should read it. He will find it a machine-gun fire of fundamental truths.
>
> And emerging from it is that mighty challenge to the engineer that his must be a fuller life extending to the guidance and direction of the manifold services which he has provided for the use of mankind.
>
> Sections and Student Branches offer the greatest of opportunities for nurturing those activities contributing to the maintenance of a high professional standing among our members. This can be done by bringing into their programs those elements contributing to a fuller professional life, by the presentation of papers, the offering of discussion, the holding of conferences, the study of the problem. Recent excellent publications in the Professional Society Journals present excellent material for study and action. The Engineers' Council for Professional Development is progressing these matters.

As President Wickenden cannot conveniently carry his message around the country, E. C. P. D. has undertaken to broadcast it, particularly to engineering students. With this in view the author has eliminated the felicities adapting it to an after-dinner occasion in a revision directed to engineers generally and to students. The Student Chapter Bulletin of the American Institute of Chemical Engineers included it in a recent issue and thus carried the message to 5,000 student subscribers. A. I. E. E.'s *Electrical Engineering* will print the address. Other societies are considering publication or distribution.

E. C. P. D.'s Committee on Professional Recognition is keenly interested as the address implements its recommendations that the

societies through their student organizations and S. P. E. E. through engineering teachers promote interest and understanding of engineering as a profession and cultivate professional consciousness and attitude among engineering students.

Herbert Hoover says in the Foreword to Professor T. T. Read's illuminating book, "The Development of Mineral Industry Education in the United States":

> Engineering as a profession received its real establishment in the New World. Socially, officially, and economically, the builders of cathedrals, the operators of mines, the makers of bridges and ships were regarded as artisans until well within the nineteenth century.
>
> My own impression is that it was not until the American universities embraced engineering as a full part of their work that engineering took upon the full dignity of a profession. The major demarcation between an artisan and an engineer is not alone the actual technical knowledge. It is the recognition of the qualifications of broad education and obedience to a code of ethics.

Corollaries are that "Engineering as a Profession" is recent, presumably dating from the impetus to engineering schools (and engineering societies) some three score and ten years ago; hence it is in a state of evolution at present. Further, if educational affiliation effected the transition of engineers from artisan to professional status, educators have a responsibility for the development of the profession. The future careers of students now in engineering schools and the sort of profession they will constitute depend on the quality of their training and on the ideals and attitude they now acquire in relation to life in general and to their profession.

If one attempts to reconcile our present technical branches of engineering and our present engineering societies with the characteristics attributed to an ideal profession he finds confusion. Some consider this as a grievous fault but it may be a normal stage in the evolution of a new profession which is primarily concerned with its own technological advance in many fields and also has to adapt itself to expanding scientific knowledge and changing industry and new social and economic forces which are themselves in turn affected by engineering progress.

The significance of the Wickenden contribution is that it presents in clarifying perspective the whole field of professions and of engineering. It arouses curiosity and puts the dissertation at once on a high plane by a mystifying title. The first paragraph gives the viewpoint of this survey of professions and of engineering:

> "Whosoever shall compel thee to go one mile—go with him twain." You will recognize this text from the Sermon on the Mount as a counsel of perfection, good advice in paradoxical form which emphasizes a pro-

found truth by an apparent denial of common sense. . . . Every calling has its mile of compulsion, its daily round of tasks and duties, its standard of honest craftsmanship, its code of man-to-man relations, which one must cover if he is to survive. Beyond that lies the mile of voluntary effort, where men strive for excellence, give unrequited service to the common good, and seek to invest their work with a wide and enduring significance. It is only in this second mile that a calling may attain to the dignity and the distinction of a profession.

After a general survey in several paragraphs this general prospectus of the paper is presented:

In view of these divided counsels, it may not be amiss to consider briefly what a profession is, how it came to be, why it exists, how its status and privileges are maintained and what obligations it entails; and finally to discuss a few of our current issues in the light of these backgrounds.

This article is no casual after-dinner talk. Wickenden when Director of Investigations for the S. P. E. E. nearly twenty years ago had an assistant make a library investigation of the characteristics of a profession which resulted in a joint paper. Later the final report of the Director concludes with a section (pages 1102–17), entitled, "The Professional Phase of the Engineer's Education." After another decade of incubation "The Second Mile" comes forth.

Much thought and study and time have gone into this paper; much thought and study is in turn required for understanding and appreciation; herein is the opportunity of instructors and counselors to use this paper for placing "a new emphasis upon those things that represent the significant difference between a professional engineer and a technologist" as is well stated by Professor Young, new president of The Engineering Institute of Canada.

The editor of *Engineering Education* proposed condensation of the article into a few pages. But eliminating any paragraph seems like taking away a beautiful flower which detracts from the symmetry and beauty of the whole bouquet. Hence this editorial type of presentation, with a few enticing extracts; here is another, as Wickenden ventures "A Look Ahead" into a beclouded future:

Let us risk a look into the next fifty years, which our student engineers are to share in shaping. Engineers will find their way into every field where science needs to be practically applied, cost counted, returns predicted and work organized systematically. They will be called upon to share the control of diseases with physicians, the control of finance with bankers, the bearing of risks with underwriters, the organizing of distribution with merchants and purchasing agents, the supplying of food with packers and purveyors, the raising of food with farmers and the operation of the home with housewives. In few of these new fields, if any, will

engineers be self-sufficient; to be useful they must be team-workers; and they must be prepared to deal with "men and their ways," no less than "things and their forces."

He has recently commented that it is particularly fitting at the present time that the engineering student get a long-range view of his professional career as he may be temporarily deflected from it.

II

By O. J. FERGUSON, Dean, College of Engineering, University of Nebraska; Chairman, Committee on English, S. P. E. E.

President Wickenden is a yeasty individual, and his addresses are worth careful reading, re-reading, and study. The present one is no exception; it is even multi-lateral. Would you know better the essence of a profession? Would you know what engineering stands for in the present world? Would you envision the coming action programs of engineers who are now youths? Would you discern the philosophy of the engineer? Would you catch a glimpse of the breadth of conscious professional engineering responsibility? Even—would you read a well-conceived, delightfully phrased essay? Whichever of these views your inquiring mind takes, you will find some compulsion to thoughtfulness in Wickenden's paper.

I commend it to teachers of English who desire to illustrate the technique of well-built, purposeful speech or expression. I commend it to the engineering educator who feels confused by the multiple aspects which his duties involve. I commend it to the student of modern society in its dependency upon professional groups. I commend it to the man who sees only darkness and danger ahead.

You cannot read it without clarifying your ideas relating to social relations and responsibilities. You cannot read it without absorbing something of its quiet spirit of assurance and confidence in the fundamentals of modern society.

E. C. P. D. is endeavoring to render a service to student, to teacher, and to the profession by making "The Second Mile" available through society publications and also in reprints at 10 cents per copy; 5 cents in quantity; $3.00 per hundred. E. C. P. D. 25–29 West Thirty-ninth Street, New York, N. Y.

EVENING GRADUATE PROGRAMS IN THE NEW YORK METROPOLITAN REGION *

By ERICH HAUSMANN

Polytechnic Institute of Brooklyn

Evening engineering instruction at the graduate level has grown tremendously in the New York Metropolitan Area during the last few years, and a considerable extension is contemplated for next year. Five colleges now give courses for employed engineers which carry credit toward advanced degrees, and over two hundred courses are available in engineering subjects alone. The experience of these institutions in this phase of engineering education may be of value in meeting the potential needs of industrial areas throughout the country.

The introduction of graduate evening courses in the schools in and near New York City followed the recognition of the specialized needs of technical workers within their coverage. The plan was started at the Polytechnic Institute of Brooklyn, where evening courses leading to baccalaureate degrees in engineering and chemistry have been in operation since 1904. Graduate courses were introduced in 1925, and soon thereafter programs were formed in several fields of learning leading to the master's degree; later some of them were extended to the doctorate. A similar development occurred at New York University; the undergraduate evening engineering division started about 1920, and graduate engineering courses given in the Graduate School of Arts and Science were shifted from day to evening hours beginning in 1933; four years later the Graduate Division of the College of Engineering was established with all its courses (except some in aeronautical engineering) given in the evening.

The School of Engineering of Columbia University has for a number of years given some of its graduate courses in the late afternoons and evenings and these are available for credit toward the master's degree; work may be extended to the doctorate under the graduate faculties of Political Science, Philosophy, and Pure Science through the guidance of the engineering faculty. At Stevens Institute of Technology evening instruction began in 1938 and prac-

* Presented at the 49th Annual Meeting, S. P. E. E., University of Michigan, June 23–27, 1941.

tically all of the courses offered were creditable toward the master's degree. A year ago Newark College of Engineering introduced in its evening session several graduate courses which by prearrangement are acceptable at Stevens for its degree.

The growth in the number and types of courses offered in these institutions has been determined more particularly by the demands of students and the interests of the staffs rather than by any abstract philosophy of graduate education. The programs of study leading to candidacy for advanced degrees, however, have been developed around basic scientific fields and divisions of technology.

Many graduates have been attracted by evening opportunities for further study in specialties such as paint and varnish technology, distillation and other unit processes, petroleum refining, advanced structural analyses, experimentation on highway materials, electrical transients and networks, vacuum tubes and short waves, physical metallurgy, powder metallurgy, fuels and combustion, vibration analysis, ordnance, and marine engineering. In many cases, such students have wide backgrounds of experience and seek the special techniques or theoretical aspects of perhaps only one of these specialties; they have little interest in academic credit and have no plan for continuing work toward a higher degree. Educational service rendered to these students is no less important than that given to others who have embarked upon degree programs, and appropriate interpretation must be made of registration figures which reveal sizable turnovers in student body from year to year.

The fields of engineering specialization for coördinated degree programs now available evenings are indicated by the following list of degrees which are given by the institutions mentioned earlier. The numerals indicate the number of degrees awarded to evening students in June of 1941.

The totals show that 79 received the master's degree and 2 the doctorate for scholastic work done almost entirely during evening hours, and that 18 others received the master's degree and 2 the doctorate for work done in late afternoon and evening courses.

Evening graduate courses attract students of superior ability and of inquiring mind. Their maturity in engineering judgment is frequently manifested in the classroom through eagerness to present supporting evidence or challenging information within their own professional experience. They hold baccalaureate degrees from schools located in all sections of the country and recognized by the appropriate agencies. A sizable proportion of these students possesses the master's degree and a few the doctor's degree. Each institution in the New York Area naturally draws its largest number of advanced students from its own graduates, and analyses are

DEGREES GIVEN IN GRADUATE PROGRAMS

Columbia University

Master of Science in Chemical Engineering	7
Master of Science in Civil Engineering	3
Master of Science in Electrical Engineering	4
Master of Science in Industrial Engineering	1
Master of Science in Mechanical Engineering	1
Master of Science in Mining Engineering	2
Doctor of Philosophy in above fields	2*

New York University

Master of Administrative Engineering	4
Master of Aeronautical Engineering	†
Master of Chemical Engineering	11
Master of Civil Engineering (including Sanitary Eng.)	12
Master of Electrical Engineering	2
Master of Mechanical Engineering (including Marine Option)	5
Doctor of Engineering Science (in first four fields)	0

Polytechnic Institute of Brooklyn

Master of Chemical Engineering	7
Master of Civil Engineering	10
Master of Electrical Engineering	6
Master of Mechanical Engineering	6
Doctor of Chemical Engineering	0
Doctor of Electrical Engineering	2

Stevens Institute of Technology

Master of Science (with concentration in fields of Chemical Engineering, Economics of Engineering, Electrical Engineering, and Mechanical Engineering)	16

available for three of them which show the institutions from which their students received baccalaureate degrees. The following table indicates the distribution, but for the sake of brevity lists only the schools which have 5 or more graduates attending any one of the institutions. The figures for Polytechnic Institute of Brooklyn include students majoring in chemistry, because its courses in that field lean so strongly to the industrial side and are so closely integrated with those in chemical engineering that a segregation would not give the correct impression; the same is true to a lesser extent at Stevens Institute.

The requirements for advanced degrees are the same as those in most institutions offering graduate work during the day. Thirty credits are required for the master's degree, including credit for thesis; but there are slight variations in the assignment of course

* One majored in civil and the other in electrical engineering.

† Since few courses in this field are given evenings, it is not possible to state how many of the 5 graduates this year did their work in evening hours.

credits. Basically a credit represents a semester hour, defined as attendance of one hour a week of lecture for 15 weeks or two hours a week of laboratory for the same period. The requirements for the doctorate are expressed in terms of full-time residence, the minimum being three years beyond the baccalaureate degree. One year of residence is allowed for the master's degree, another year can be earned by again as much scholastic effort, and the third by a dissertation evidencing investigational work of a high order.

COLLEGES REPRESENTED BY GRADUATE STUDENTS
1940–1941

Baccalaureates From	Attending Courses At		
	New York Univ.	Polytechnic	Stevens
Polytechnic Institute of Brooklyn	13	163	12
New York University	137	27	13
Stevens Institute of Technology	9	4	112
College of the City of New York	30	97	13
Newark College of Engineering	17	15	57
Cooper Union	24	45	14
Columbia University	11	25	5
Massachusetts Institute of Technology	18	7	11
Cornell University	9	13	9
Rensselaer Polytechnic Institute	6	15	9
Manhattan College	13	7	3
Rutgers University	7	10	6
Brooklyn College	1	17	0
Yale University	10	5	3
Lehigh University	0	8	6
Union College	2	6	6
Harvard University	5	4	1
Princeton University	5	2	2
Carnegie Institute of Technology	0	7	1
Rhode Island State College	2	1	5
Long Island University	0	7	0
Foreign	13	8	7

An important development in graduate work within the Area is the coöperative program between three institutions and the Westinghouse Electric and Manufacturing Company introduced two years ago. It will be described later in this afternoon's program by Dr. John H. Belknap, Manager of Technical Employment and Training of the Company.

A picture of the present scope of graduate work available in the New York Metropolitan Area to engineers in employ is afforded by the following table which includes only courses in the four major departments of study and does not include those in the collateral

sciences of mathematics, chemistry, physics and meteorology. The table gives the number of evening courses offered in 1940–41 and available next year; it includes only those beginning at 6 P.M. or later and those on Saturdays; it shows that almost two hundred graduate courses are available after the dinner hour in these fields of engineering alone.

The detailed offerings summarized in this table are listed by title in APPENDIX I; it shows the wide range of courses available and indicates the possibilities for specialization in a number of branches within the major fields, such as physical metallurgy, sanitary engineering, structural engineering, electrical communication, and machine design. The picture of evening study would not be complete without mention that Columbia University gives other graduate courses which it regards as available to men in industry, although these courses begin as early as four o'clock. The enrollment in its

EVENING ENGINEERING COURSES NOW AVAILABLE

	Chemical	Civil	Electrical	Mechanical
Columbia University	5	2	6	6
Newark College of Engineering	2	4	3	7
New York University	14	17	10	11
Polytechnic Institute	18	14	14	19
Stevens Institute	11	2	15	14
TOTALS	50	39	48	57

School of Engineering for these late afternoon and evening courses was 116 during 1940–41.

Having given a collective view of graduate evening engineering instruction centering about New York City, I wish now to confine myself to the development of this work at the Polytechnic Institute of Brooklyn. Following the introduction of a graduate program in chemistry and a few courses in physics, mathematics and engineering, separate curricula were set up in 1928 in the four major engineering fields, each containing required and elective courses and leading to the master's degree in the particular field. Soon thereafter departmental advisers were appointed to confer with students and approve the course selections determined upon from year to year.

In 1933 graduate work was extended to the doctorate in chemistry and three years later to the doctorate in chemical and in electrical engineering. This development at first followed the general plan for the master's degree which is characterized by particular applications of science and technology, but later the need

for more basic courses became apparent. A group of courses was introduced built around the fundamental avenues of thought in engineering science. These distinctive courses lead away from the more particularized courses dealing with specific problems, techniques and methodologies, and aim to give students a thorough mastery of the basic concepts of physical science so as to enable them, through a critical understanding of generic principles and a higher development of the power of analysis which come from such basic studies, to contribute to the expansion of theoretical knowledge and the development of experimental research. There are five such courses, and one or more may be included in the master's curriculum as well as in the doctoral program. They are Fundamentals of Mechanics, Fundamentals of Electronics, Statistical Mechanics, Fundamentals of Radiation, and Quantum Mechanics.

The course in Fundamentals of Mechanics develops the classical theory of boundary value problems to provide the foundation for work in dynamics of solids, hydraulics, aerodynamics, elasticity, plasticity, and soil mechanics. In the course on Fundamentals of Electronics, the Lorentz theory of free electrons is developed and applied to electron tubes, electron optics, and fluctuation noise; also the fundamentals of the electron gas concepts are derived, applied to electronic conduction and emission, and modified to conform to quantum concepts. The course in Statistical Mechanics develops the laws governing the properties of matter from the statistical viewpoint and applies them to the theories of the chemistry of solutions, of the structure of metals, of the kinetic theory of gases, and of thermodynamics. The course in Fundamentals of Radiation deals with the basic equations of the electromagnetic theory of light and the elements of atomic spectra, to provide the theoretical background for the study of spectroscopy, x-ray crystal analysis, and the propagation of radio waves. The course in Quantum Mechanics covers the experimental foundation and development of the quantum theory and its application to nuclear structure, electrical conduction, and the theory of metals.

Doctoral matriculants work under the direction of individual guidance committees made up of professors in the departments selected for the major and minor studies, the chairman of a student's committee being his thesis adviser. The committee guides the student in preparing himself for the qualifying examinations and in meeting the language requirements, and conducts the oral examination on his thesis and on subjects related to it.

The majority of projects undertaken by students in their thesis work for advanced degrees are performed at Polytechnic, but some are performed in the research laboratories and industrial plants in

which students are engaged. This practice materially expands the facilities available to students and has in no way necessitated a departure from the quality standards governing work at the Institute. When a student desires to pursue his research in the laboratory or plant in which he is occupied he must secure the written permission of the responsible person in the industry and his work is directly supervised through visitations from his thesis adviser.

The growth of graduate instruction is best shown by tabulations of courses given, of students registered, of course enrollments, and of degrees awarded. It is believed that such tabulations for three schools will be of interest, especially since one of them shows an experience record of fifteen years; consequently they are included as APPENDIX II. Over 60 courses are now given annually at Polytechnic, the student enrollment in engineering, chemistry and physics is now 651, the course enrollment exceeds 1,100, and 348 students have received advanced degrees in evening courses since their introduction. Those qualifying for master's degrees take on the average 3¾ years for completing the requirements; this year's group ranged in ages from 21 to 36 and one at 46, averaging 27 years.

Some statistics of evening instruction at New York University were supplied by Director Henry J. Masson of the Graduate Division of its College of Engineering and similar information on graduate work at Stevens Institute was furnished by Dean Frank C. Stockwell of its Graduate School; these tables are included in APPENDIX II. Appreciative thanks are expressed to them for their assistance in the compilations of both appendices.

Graduate students are almost without exception profoundly earnest in their desire for mastery of their subjects and strive for high scholastic ratings. It must be said, however, that a large number of men each year are prevented from giving sufficient attention to their study and problem assignments because of business and family obligations, or are obliged to be absent from sessions and final examinations.

Appraisal of the abilities of students in various types of advanced courses by their professors would naturally show differences for many reasons. But a fair insight to student performance is provided by an analysis of grades assigned in graduate courses over a period of years and covering the main engineering fields and their collateral sciences. Such an evaluation has been made at Polytechnic over the college years 1929–30 to 1939–40 and covering 466 evening courses in over a hundred subjects. In all, 7,042 grades were assigned in courses, exclusive of theses and seminars, and 78 per cent were passing; the details of this analysis are also given in APPENDIX II and show that 63 per cent were honor grades about

equally divided between A and B. Non-passing grades numbering 1,567 were divided as follows: dropped 630, failure 522, incomplete 236, condition not removed 123, no credit 56.

The Graduate Session is governed and regulated by the Graduate Faculty, which is responsible for the direction of all matters of advanced instruction and investigation as well as discipline. It is integral with the General Faculty of Polytechnic, and is composed of those who teach and supervise graduate work. The personnel of its membership includes the heads of departments of graduate instruction, teachers of professorial rank in those departments, and other teachers and professional men who serve on yearly appointments or for longer periods. In the Graduate Faculty certain responsibilities are delegated to an Executive Committee and to several standing committees. One covers Admissions and Standing, another Curriculum and Educational Policy, and a third Research. The chairmen of these standing committees are all members of the Executive Committee under the leadership of the Dean of Graduate Study. He is the custodian of all credentials and scholastic records. He receives the applications for candidacy for advanced degrees and appoints the guidance committees to direct the work of the doctoral candidates.

In the New York Area there are many opportunities to associate with an evening staff a group of specialists in the diversified scientific and industrial enterprises within its borders. Polytechnic has drawn upon such specialists from great research laboratories, engineering offices of industrial companies, operating divisions of public utilities, and from consulting offices. Some members of the affiliated staff who have had the responsibility for special courses for several years have received the title of Adjunct Professor, others are classified as instructors. Those who may be assigned one or several lectures in a course supervised by a member of the resident staff are ranked as lecturers. Visiting professors have been appointed periodically to give particular courses; recent appointees have come from such institutions as the University of Pennsylvania, Brown University and the United States Department of Agriculture. This broad policy of affiliating specialists with the resident staff has brought together a faculty of outstanding merit.

Recently letters were sent to graduates of the Graduate Session of Polytechnic asking how advanced study has helped them personally in their professional work and how their further training has helped the concerns with which they are associated. Many reported that such study was instrumental in securing better positions or advancement in their own organizations, in providing superior preparation and experience credit for civil service and

state licensing examinations, and in furthering professional recognition through higher grades of membership in the technical societies. Quotations from some of these responses will give the personal viewpoint of those who receive graduate instruction and have the opportunity to make it effective.

"My graduate work has proved extremely beneficial because it has enabled me to tackle my daily problems with the confidence bred of knowledge, to keep abreast of modern developments by being able to read and understand technical papers and to participate in technical discussions, and to appreciate the cultural values of life."

"I have been employed in bridge and structural steel design and consequently the graduate courses I took along these and allied lines have proven to be very useful, whereas other civil engineering courses have been of less use. The instruction was of uniformly high caliber and effectiveness. The courses taught by men engaged in industry during the day were particularly fine."

"Advanced technical knowledge and training in scientific investigational methods are highly desirable for positions in my company. The advanced courses, particularly in the materials field and in general physics, have been of very considerable value to me and indirectly to the company, for I apply them in the development and application of welding and in the use of x-ray methods for materials inspection."

"My superiors, who have themselves taken advanced degrees years ago, do not hesitate to ask my advice or recommendations on problems, whether in plastics, plant equipment, organic synthesis or petroleum. Many items are turned over to me for solution despite my lack of previous experience in the field involved, primarily because of the breadth of my graduate training."

"The advanced studies are to me 'the priceless ingredient' and will always influence any work I may undertake. The structural courses have enabled me to carry on my work analyzing the exact stresses in statically indeterminate structures, and on recent work I was able to utilize part of my thesis material."

"I consider that the post-graduate work opened still further my perspective on engineering problems and furnished me with greater skill and facility in the use of mathematical tools for their solution. My appreciation of fundamental concepts was strengthened by the advanced courses in electrical engineering. As a result of this study, the light and power utility has on its payroll a man more thoroughly trained in engineering and its concomitant subjects and to whom it can entrust some measure of responsibility in the solution of its technical problems."

"The special training which I have obtained in advanced courses in chemical engineering and organic chemistry, have benefited both me and the company, to the extent that I am now in complete charge of its research program."

"Graduate work has helped me professionally by applying the theory and principles to get better and more economical structural designs. It has helped me in making sound decisions on engineering matters, and has

enabled me to more readily comprehend and enjoy papers and discussions of an advanced nature in my field. I have benefited very much from the graduate work, and this benefit is largely due to the excellent staff."

"My investigational work on the drying of oils and varnishes which I performed for my Master's Thesis is aiding both my employer and myself, in that I am now working on problems affecting the drying and printing characteristics of lithographic printing inks. As a result of taking Varnish Technology I was able to formulate successfully a special process lacquer. I feel that the teaching staff has the truly excellent combination of practical experience and theoretical knowledge which is so essential to help college students adapt their theoretical knowledge to practical conditions in industry."

"There is no doubt that my post-graduate studies have given me a broader understanding of the general field of engineering and have made me more valuable to my employer. Courses such as Soil Mechanics, Engineering Economics, and Concrete and Bituminous Pavements were quite indispensable for the proper understanding of various phases of my work."

"The graduate work has, perhaps, been more useful in the habits of thought which it helped produce, than in the actual subject matter studied. The course in Engineering Economics has been valuable because much of my work has dealt with the choice of methods for doing particular jobs."

"Graduate work has definitely given me a greater capacity to handle more responsible work and added to my ability to 'think thru' a job before it is undertaken. From a practical point of view some of the courses, particularly in stress analysis and metallurgy, have been applied toward actual improvement of machinery being designed and manufactured."

"Any man taking a graduate program who does not have in mind a definite goal such as is provided in a thesis, loses, in my estimation, the best part of his graduate work. My thesis on Self Synchronous Systems enabled me to develop the formulas needed to calculate the windings and design for the generators and motors which make up this system. Taking a master's thesis after completing several graduate courses brings to it a greater scholastic maturity than is possible in the usual one-year day programs."

"Work along the lines of my thesis had always interested me and led to developments for the company which are being used. In connection with this work I obtained two patents on apparatus for testing locomotives and on a smokebox arrangement for locomotives."

"Graduate instruction has given me the necessary confidence in my ability to do a good job as a research metallurgist. The course in advanced General Physics has paid more dividends than any other."

"I have found that the courses were primarily valuable as a background for the critical examination of various problems that come up in my daily work rather than as a source of material that could be applied directly. In this respect the fundamental courses in mathematics, physics and thermodynamics were particularly useful. The machine designed in my thesis primarily for research was used in commercial work for the selection of low friction packing on the large pumps built for the Metropolitan Water District in California."

"I found the courses in advanced calculus and in vibration particularly useful, although I believe that the primary value of graduate courses has been in giving me a wider background and new approaches to old problems."

"The graduate work which I took in 1928 qualified me for a higher position in engineering design and then brought me into engineering teaching. Later, I was promoted to the rank of Assistant Professor of Civil Engineering and by election by the members of the Civil Engineering Faculty am now Chairman of the Department."

"I was engaged in the design and construction of LaGuardia Airport during my graduate studies and chose as a thesis the design of a modern air terminal. I had acquired a great deal of information concerning the problems to be encountered and methods of solution, and when the Washington National Airport started in the spring of 1939, I was sent to Washington at the request of the C.A.A. to assist in the preliminary design. Now I am an engineer-designer on the air bases in the Caribbean."

The demand for graduate work in engineering and its basic sciences has been demonstrated by the experience of the schools in the New York Area. It is my belief that educational institutions have an obligation to industry to make such instruction available to employed engineers, and that evening programs provide a logical continuity for their professional development. The outlook for the future seems to be circumscribed only by facilities and personnel.

APPENDIX I

Evening Graduate Courses

Evening courses now available in the New York Metropolitan Area in chemical, civil, electrical and mechanical engineering are listed below and divided into first semester, full year and second semester courses; the credit for each course is indicated in semester hours. Alternate year courses are lettered A for those offered in 1940–41 and B for those offered in 1941–42. The symbol F follows the title of a course to indicate that it will be given next year for the first time; N similarly placed denotes that the course was offered in 1940–41 but not given. Thesis projects, research work or seminars are not listed.

Graduate Courses in Chemical Engineering

First Semester	*Full Year*	*Second Semester*
Columbia University		
Applications of Thermodynamics (F) 3	Principles of Chem. Eng. 4	Fundamental Operations of Chem. Eng. (F) 3
Design & Selection of Chem. Plant Equipment (F) 3	Fuel Technology (A) 4	
Newark College of Engineering		
	Chem. Eng. Thermodynamics (B) (F) 4	
	Paint Technology (A) 4	

New York University

Stoichiometry 3	Industrial Chem. 6	Unit Processes Lab. (B) 3
Electrochemistry (B) 3	Chem. Eng. Thermodynamics 6	Mathematics Applied to Chem. Eng. 3
Fuels & Combustion (B) 3	Diffusional Processes 6	Fluid Flow and Heat Transfer Processes (B) 3
	Unit Processes of Organic Synthesis (F) 6	Metallography 3
	Food Eng. (A) 6	
	Food Technology (B) (F) 6	
	Metallurgy 6	

Polytechnic Institute of Brooklyn

Fluid Operations 3	Unit Processes in Organic Synthesis (A) 3	Solid and Gaseous Operations 3
Inorganic Chem. Technology (B) 1½	Chem. Eng. Calculations (B) 4	Water Conditioning (A) 1½
Metal Finishing (A) 2	Interpretation of Chem. Eng. Data (A) 4	Electrochem. Technology (B) 2
	Chem. Plant Design (A) 4	Electrometallurgy (A) 2
	Petroleum Refining (B) 4	Chem. Eng. Economy (B) 2
	Petroleum Equipment Design (B) (F) 4	Industrial Hygiene (B) (N) (F) 2
	Varnish Technology (A) 3	
	Paint and Pigment Technology (B) 3	
	Pulp & Paper Technology (B) (F) 4	

Stevens Institute of Technology

Chem. Technology of Inorganic Industries (B) 2	Unit Operations (B) (F) 4	Chem. Technology of Organic Industries (B) 2
Corrosion & Heat Resistant Alloys (B) (F) 2	Metals (B) 4	Chem. of Water Treatment (A) 2
	Metallographic Lab. (A) 3½	Non-Ferrous Metals (B) (F) 2
	Adv. Metallographic Lab. (F) 3½	
	Powder Metallurgy 4	
	Powder Metallurgy Lab. 3½	

Evening Graduate Courses in Civil Engineering

First Semester	*Full Year*	*Second Semester*
Columbia University		
	Soil Mechanics & its Applications (A) (Discontinued) 2	
	Experimental Soil Mechanics 3	
	Reinforced Concrete Eng. (B) (F) 2	
Newark College of Engineering		
Adv. Hydraulic Theory & Lab. (N) (F) 3½	Adv. Reinforced Concrete (B) (F) 4	Adv. Sewage Treatment Plant Design (N) (F) 3½
		Soil Mechanics (B) (F) 3
New York University		
Hydrology 3	Structural Theory 6	Fluid Mechanics 3
Water Supply and Treatment 3	Materials Testing & Model Analysis (B) 6	Adv. Hydrology (B) 3
Civil Eng. Hydraulics 3	Sewage Analysis 6	Sanitary Eng. Lab. 3
Reinforced Concrete 3	Sanitary Water Analysis 3	Sewage & Waste Disposal 3
Soil Mechanics 3		Sanitary Eng. Design 3
		Food Sanitation (A) 3
		Industrial Building Design (A) 3
		Foundation Eng. 3

Polytechnic Institute of Brooklyn

Adv. Mechanics of Materials	2	Adv. Structures	6	Adv. Testing of Concrete (B)	2
Adv. Hydraulics (B)	2	Adv. Concrete Structures	4	Photoelasticity (B)	2
Adv. Hydraulic Lab. (B) (N) (F)	2	Bridge Eng. (A)	4	Adv. Soil Mechanics	2
Economics of Highway Eng. (A)	2	Water Power Eng. (A)	4	Bituminous Pavements (A)	2
Traffic Eng. (B)	2			Traffic Aspects of City Planning (B) (N) (F)	2

Stevens Institute of Technology

		Rigid Frame Analysis (B)	4
		Adv. Structures (A)	4

Evening Graduate Courses in Electrical Engineering

First Semester		*Full Year*		*Second Semester*	
Columbia University					
Storage Batteries (N)	2	Application of Electron Tubes	4	Communication Electronics	2
Eng. Electronics	2	Sound Eng.	4		
		High Frequency Lab. (F)	4		
Newark College of Engineering					
		Electricity & Electromagnetism (B) (F)	4		
		Electron Tube Circuits (B) (F)	4		
		Electronics & Vacuum Tubes (A)	3		
New York University					
Application of Electrical Equipment (Westinghouse) (A)	2	Electrical Transients	6	Fundamentals of Power System Analysis (A)	3
Protective Relaying as Applied to Power Systems (Westinghouse)	2	Adv. Electric Machinery Theory	6		
Electron Tubes & Their Circuits (F)	3	High-Voltage Eng. (A)	6		
Design & Application of Electronic Tubes (B) (F) (Westinghouse)	2	Audio Frequency Eng.	6		
		Radio Frequency Eng.	6		
Polytechnic Institute of Brooklyn					
Theory of Electrical Measurements (B) (F)	2	Analysis of Transient Phenomena	4	Ultra-High Frequency Theory (B) (F)	2
Conformal Mapping (B)	2	Electromagnetic Theory	4		
Design & Application of Electronic Tubes (B) (F) (Westinghouse)	2	Power Transmission & Distribution Theory	4		
Protective Relaying as Applied to Power Systems (Westinghouse)	2	Adv. Alternating Current Machinery (B) (F)	4		
		Design of Electrical Machines (B) (F)	4		
		Fundamentals of Electronics (A)	4		
		Electronic Tubes & Their Circuits	4		
		Network & Filter Theory (A)	4		
		Adv. Network Theory (B)	4		

Stevens Institute of Technology

Electroacoustics (A) 2
Protective Relaying as Applied to Power Systems (Westinghouse) 2
Application of Electrical Equipment (Westinghouse) (A) 2
Radio Frequency Eng. (F) 2
Design & Application of Electronic Tubes (Westinghouse) (B) (F) 2
Transients in Electric Circuits (A) 4
Electromagnetic Theory (A) 4
Electromagnetic Devices (B) 4
Engineering Electronics (B) (F) 4
Vacuum Tube Circuits (A) 4
Communication Networks (B) 4
Television Eng. (B) 4
Coupled Circuits (Discontinued) 2
Communications Lab. (F) 1¾
Complex Variable: Eng. Applications (B) (F) 2
Electric Wave Filters (B) 2

Evening Graduate Courses in Mechanical Engineering

First Semester	*Full Year*	*Second Semester*
Columbia University		
Eng. Fluid Dynamics 3	Heat Transfer 6	Eng. Mechanics, Lubrication 3
Aerodynamics 2	Air Conditioning 7	
Eng. Metallurgy 2½		
Newark College of Engineering		
Adv. Thermodynamics (A) 2	Properties of Eng. Materials (B) (F) 3½	Steam Power Plants (N) (F) 2
	Heat Transmission (A) 4	
	Physical Metallurgy (A) 4	
	Physical Metallurgy Lab. (B) (F) 3½	
	Aeronautics (B) (F) 4	
New York University		
Eng. Thermodynamics 3	Marine Power Plants 6	Heat Transfer 3
Centrifugal Pumps and Compressors 3		Machine Design 3
Railway Motive Power 3		Internal Combustion Engines (F) 3
Applied Naval Architecture 2		Adv. Marine Power Plants (F) 3
		Propellers, Shafting & Gearing (F) 3
(Courses in aeronautical engineering given in separate department)		Air Conditioning 3
Polytechnic Institute of Brooklyn		
X-Ray Metallography 2	Adv. Thermodynamics 4	Metallurgical Thermodynamics (B) 2
Mechanics of Real Fluids (A) 2	Steam & Gas Turbines (A) (N) 4	Applied Fluid Mechanics & Fluid Metering (A) 2
Industrial Marketing (A) (Westinghouse) 2	Steam Power Plants (B) 4	Graphical & Mechanical Computations (B) (N) (F) (Westinghouse) 2
	Combustion & Heat Transfer (A) 4	X-Ray Metallography Lab. (Westinghouse) (B) (F) 2
	Kinematics in Machine Design (A) (Discontinued) 4	
	Dynamics of Machines & Vibrations (A) 4	
	Machine Design for High Speeds (B) (F) 4	
	Hydraulic Machines and Mechanisms (B) (F) 4	
	Metallography & Heat Treatment (A) 4	
	Industrial Metallurgy (B) 4	
	Adv. Materials Testing & Inspection (A) 4	
	Mechanics of Perfect Fluids (B) 4	
	Adv. Methods of Aircraft Stress Analysis 4	

Stevens Institute of Technology

Mechanics of Elastic Bodies (A)	2	Steam Power Plants (B)	4	Mechanics of Fluids (A)	2
Fuel Injection Engines (A)	2	Adv. Dynamics (B)	4	Adv. Thermodynamics (B) (F)	2
Air Conditioning (A)	2	Mechanical Vibrations (B)	4	Principles of Naval Architecture (B) (F)	2
Experimental Towing Tank Problems (B) (N)	2	Ordnance Eng. I (A)	4	Marine Power Eng. (A)	2
		Ordnance Eng. II (B)	4	Air Conditioning Lab. (A) (N)	1½

APPENDIX II

Statistics of Graduate Instruction

Number of Evening Courses Given at Polytechnic Institute

Courses given by departments named, exclusive of thesis and Westinghouse offerings, in the years beginning with the dates indicated:

Year	1925	'26	'27	'28	'29	'30	'31	'32	'33	'34	'35	'36	'37	'38	'39	'40
Chemistry	3	3	3	3	3	3	5	9	8	8	14	18	16	18	21	24
Chem. Eng.	1	1	1	1	1	1	1	2	4	5	7	6	5	9	8	8
Civil Eng.				1	1	5	3	3	3	5	4	7	6	7	9	7
Elec. Eng.	1	1		1	5	7	6	5	5	5	6	4	7	8	6	7
Economy of Eng.			1	1	1	1	1	1	2	2	2	2	2	2	3	2
Mathematics				2	3	4	4	4	4	4	4	5	5	5	6	4
Mech. Eng.		1		3	4	4	4	4	6	5	6	8	7	7	7	9
Physics	1	2	2	3	3	3	5	4	4	7	6	5	6	6	5	5
Totals	6	8	7	15	21	28	29	32	36	41	49	55	54	62	65	66

Students Registered at Polytechnic Institute

Number of students in departments named during years beginning with the dates indicated; all have graduate standing except those listed as auditors and seniors:

Year	1928	'29	'30	'31	'32	'33	'34	'35	'36	'37	'38	'39	'40
Chemistry	?	40	41	48	58	67	95	129	148	164	177	239	287
Chem. Eng.	?	10	9	11	13	21	26	44	55	70	86	106	106
Civil Eng.		31	47	37	45	45	52	60	73	79	71	79	67
Elec. Eng.	?	84	110	92	80	66	66	71	89	91	90	104	97
Mech. Eng.		38	43	49	41	32	30	33	56	66	65	54	58
Physics		1		3	3	5	10	17	12	15	16	17	20
Auditors and Seniors	16		4	1	2	21	16	13	10	19	13	15	16
Totals	129	204	254	241	242	257	295	367	443	504	518	614	651

Course Enrollments at Polytechnic Institute

Numbers of students enrolled in courses given by departments named, excluding thesis registrations, at end of fall registration periods for the years indicated:

Fall of	1925	'26	'27	'28	'29	'30	'31	'32	'33	'34	'35	'36	'37	'38	'39	'40
Chemistry	26	38	22	39	57	52	77	118	113	139	274	344	356	422	469	571
Chem. Eng.	10	12	8	8	12	9	7	12	33	41	73	74	103	136	133	155
Civil Eng.				11	15	47	23	50	28	59	65	86	77	73	85	64
Elec. Eng.	?	5		11	41	83	64	53	57	51	72	51	74	84	100	98
Economy of Eng.			12	19	36	27	14	14	36	26	36	26	43	25	36	30
Mathematics				48	87	68	87	60	55	62	73	70	66	86	74	48
Mech. Eng.		10		31	34	42	43	22	48	26	47	66	79	74	53	68
Physics	?	34	21	42	67	60	60	33	31	36	60	51	69	66	72	84
Totals		99	63	209	349	388	375	362	401	440	700	768	867	966	1022	1118

Advanced Degrees Bestowed by Polytechnic Institute

Degrees granted year by year since the introduction of evening graduate work:

	1927	'28	'29	'30	'31	'32	'33	'34	'35	'36	'37	'38	'39	'40	'41	Total
Master																
Chemistry	5	3	2	3	8	5	9	8	7	10	9	19	14	15	17	134
Chem. Eng.									1	3	2	3	5	8	7	29
Civil Eng.						2	5	1	7	6	9	9	7	7	10	63
Elec. Eng.				1	2	2	5	4	6	8	6	7	3	5	6	55
Mech. Eng.				1	1	1	3	3	4	3	4	1	3	6	6	36
Physics									1	1	1		1	1	2	7
Totals	5	3	2	5	11	10	22	16	26	31	31	39	33	42	48	324
Doctor																
Chemistry									1	1	4	1	2	4	7	20
Chem. Eng.											1					1
Elec. Eng.											1				2	3
Totals									1	1	6	1	2	4	9	24

Students Registered at New York University

Number of students enrolled at end of fall registration periods for the years indicated, with those wishing credit toward the doctorate grouped separately:

	Fall of 1937	1938	1939	1940
Aeronautical Eng.	13	22	41	47
Administrative Eng.		13	36	48
Chemical Eng.	8	38	38	63
Civil Eng.	52	81	74	76
Mechanical Eng.	9	19	34	47
Electrical Eng.		11	11	29
Department not specified	13	15	20	8
Doctoral students	6	11	18	24
Totals	101	210	272	342

Master's Degrees Bestowed by New York University

Degrees granted to evening students since formation of Graduate Division of College of Engineering:

	1938	1939	1940	1941
Administrative Eng.				4
Chemical Eng.		3	5	11
Civil Eng.	5	9	15	12
Electrical Eng.			2	2
Mechanical Eng.			3	5
Totals	5	12	25	34

In addition, degrees of Master of Aeronautical Engineering were awarded in these years to 8, 9, 9 and 5 candidates respectively who took some courses during the evening.

Number of Evening Courses Given at Stevens Institute

Courses given by departments named, exclusive of thesis but including Westinghouse offerings, in the years beginning with the dates indicated:

	1938	1939	1940
Chemistry and Chemical Eng.		7	7
Civil Eng.	1	1	1
Electrical Eng.	3	10	8
Economics of Eng.	3	6	6
Mathematics	4	3	4
Mechanical Eng.	6	6	6
Physics	2	1	
Totals	19	34	32

Course Enrollments at Stevens Institute

Number of students enrolled in courses given by departments named, excluding thesis registrations but including Westinghouse courses, at end of fall registration periods for the years indicated:

	1938	1939	1940
Chemistry and Chemical Eng.		74	103
Civil Eng.	12	7	6
Electrical Eng.	93	118	105
Economics of Eng.	62	38	75
Mathematics	73	39	65
Mechanical Eng.	80	103	99
Physics	4		
Totals	324	379	453

Analysis of Grades Given in Graduate Courses at Polytechnic Institute 1929 to 1940

Distribution of grades assigned in the courses given by the departments named. Grades for thesis projects and seminar work are not included, and no grades are given to auditors.

	Total number of grades	Merit A	Credit B	Pass C	Non-Pass
Chemistry	2350	783	869	268	430
Chemical Eng.	797	188	334	93	182
Civil Eng.	682	233	249	80	120
Electrical Eng.	713	219	224	93	177
Economics of Eng.	319	72	119	66	62
Mathematics	901	242	225	169	265
Mechanical Eng.	625	163	200	123	139
Physics	655	176	153	134	192
Totals	7042	2076	2373	1026	1567

TEACHING QUALITY CONTROL THEORY TO ENGINEERS *

By LOUIS C. YOUNG

M. I. T. (on leave to Westinghouse E. & M. Co.)

In order to judge the effectiveness of an educational program, it is desirable to have at hand standards of comparison. In a relatively new field, such as industrial statistics or quality control, judgment of observed results can best be passed upon the degree to which certain requirements have been satisfied. The requirements in this case can be understood most easily by considering the normal aspects of quality control in industrial practice.

When a manufacturing firm first starts production of an item, quality of the product is affected by elements of variation which are relatively great. As time passes and familiarity with the product is gained, the more apparent of these elements are discovered and eliminated. Acquisition of new machinery, new personnel, or new sources of raw materials, however, may cause some of the eliminated factors of variability to reappear, or some new source to become evident: some check on preëxperienced effects and upon the entrance of new variables is therefore necessary. Furthermore, a large number of less noticeable factors of variation will remain undetected, even over a long period of time, unless some form of statistical analysis is used. It is evident, then, that objective statistical control is composed of two interdependent operations: the evaluation of sources of quality variability and a supervisory control of objectionable variation. Subordinate to these main phases are the minor operations of economical sampling, risk, and others.

Evidently any description of the foregoing statistical processes might be divided into two sections: first, an intercomparison of the initial effects of various factors influencing quality and second, a comparison of the current effects of each factor with past history of those effects. An educational plan dealing with the fundamental aspects of quality control should properly incorporate these components of the definition in order to be thorough.

Statistically, the two types of procedure are separate modifications of the same basic concepts. The first, or factorial type of

* Presented at the 49th Annual Meeting, S. P. E. E. (Electrical Engineering), University of Michigan, June 23–27, 1941.

analysis, rests largely on the principles presented by R. A. Fisher, and by others working along the same line. By means of these analytical methods of experimentation, it is ordinarily possible to evaluate the effects of the various factors incorporated in the experiment. The second, or control chart type of analysis, developed by W. A. Shewhart and his associates, may be used in the current control of quality to reveal the presence of new or previously unnoticed sources of variation. The two procedures are used hand in hand during the course of manufacture: the second to reveal the presence of trouble, and the first to allocate the source of the trouble.

In line with the foregoing conception of quality control, the programs of industrial statistics offered at the Massachusetts Institute of Technology represent slightly separate modifications adapted to the needs of those following different lines of study. The course adopted by those choosing to major in industrial statistics is well defined in the accompanying exhibit, entitled "Course XVIII, Option 3." The trend toward specialization begins in the second year, and increases in the third and fourth years of study. It will be noticed that training in engineering is confined principally to mechanics, as a root; supplementary courses in the third and fourth years serve as preparation for manufacturing and industrial experience. The graduate of this course of study is intended to be primarily a mathematical statistician, with sufficient knowledge of engineering fundamentals to follow through in any specific field. The majority of those who follow the prescribed line of study plan to place themselves in some field of production, where their engineering education is expected to progress more rapidly than their mathematical, statistical training.

Students majoring in engineering, on the other hand, have open to them a course which deals with all of the major phases of quality control, but which places less emphasis on the mathematical background of statistical methods. The derivations of statistical technique are surveyed to a degree which is not intensive, but which permits the limitations of each phase of quality control to be demonstrated. The nature of the course is outlined briefly in the exhibit "Course for Non-Specialists." It will be seen, in the course listed as "Experimental Statistics" (Ec 38), that factorial experimentation and quality control routine are given approximately equal attention, in order to provide coverage of both aspects of the customary industrial control program. In addition, the engineer is given useful training in research experimentation, a proven necessity for fields in which control of experimental variables is difficult or impossible.

The number of those majoring in industrial statistics has aver-

aged about seven per year during the three years that the course has been in active operation. The number of positions available in industrial firms for the capable statistical engineer is ample, but it has proved difficult to produce the type of graduate generally desired. It has been remarked that engineering students are ordinarily opposed to much mathematical training, and tend to disregard most of the mathematical methods for which they can find no immediate application. Perhaps the fact that many engineering methods are specific applications of generalized mathematical lines of thought tends to cause a rift between the two types of study. This possibility is at least partially supported by the experience that mathematical students, on the average, have a similar aversion for engineering subjects. A student representing the happy medium appears to be the product more of circumstance than of deliberate training. Above and beyond this obstacle of combined interest in two fields, however, is still another. Those graduates wishing a place in industry must be capable of assuming real responsibilities at the outset, since their field is so specialized. Only in unusual cases may they expect to be located under someone with more than a superficial knowledge of statistical methods, since the average plant need is for one full time man. Even during the usual training period in a plant, they must often stand entirely on their own feet, paying attention to the process factors which are significant from the viewpoint of quality control technique as they have learned it. Frequently, too, the presence of hindrances to a control program, in personnel and other forms, tends to make a company hesitate before employing a man lacking color or having a mediocre record.

Needless to say, the engineer who only partially specializes in statistical methods is later likely to find his engineering training in greater demand than his statistical ability. The academic treatment of the subject must necessarily detach itself from the particular combination of statistically irrelevant circumstances attending the industrial application. At the same time, however, word has been reported in more than one case that those conditions which are not pertinent statistically may be of vital importance to the quality control program. The attitude of labor, for example, is likely to be hostile if statistical control is introduced in the guise of a policing system. The difficulties thus presented to one lacking practical experience and prestige can readily be imagined. Although management as a whole may see the advantages, furthermore, portions of a departmentalized organization may be opposed, for selfish reasons, to the use of control or sampling methods. Moreover, the faction in between these two—those men whose cur-

rent methods of control will be directly affected by statistical application—will very likely hesitate to lend coöperation unless they know with what they are dealing, and where they stand. These are the factors which cannot be taught as an inherent part of quality control, yet it is certain that they influence the success of every control program.

Some of the foregoing details concerned with practical application have been gleaned from contact with those graduates who have had the opportunity to use their training in control methods. Added information along similar lines has been obtained from staff activity in connection with problems brought in by manufacturing concerns. Although the large majority of cases so considered are directly related to engineering statistics, they represent a diversified group of applications, ranging from analysis of refrigerator efficiency to the optimum determination of ore body location in mining. The fact that each problem is quite individual prevents use of any routine method of solution, and therefore places emphasis on the need for properly planned experimental methods of solution. Since the technique of statistical control and experimentation is often misunderstood, it is not uncommon for the industrial statistician to be presented with a set of problematic data which are quite inadequate for their purpose. Under such conditions, it is sometimes necessary to obtain an entirely new set of data, in a manner which maximizes the reliability of the engineering conclusions. The nature of many engineering control problems is such that the answer can be correctly found only after one or more experimental investigations: a potential source of variation in quality, for example, may be suspected of exerting a great influence on quality, yet may prove to be of negligible effect when examined statistically. The real source may be overlooked at first, and the discovery of its identity after elimination of other, more likely sources may come as a surprise to the engineer. Preliminary data, in other words, may possibly contain no pertinent information on the real answer to the problem. It is sometimes very difficult to explain this to the industrial engineer, especially if he is confident that all important factors have been incorporated in the data. Even when he is correct in this belief, the data have frequently been obtained under such conditions that a significant interaction effect of the various factors cannot be evaluated. The situation finds an appropriate analogy in the case of a doctor treating a patient for acute indigestion. If the patient states that he has eaten only fruit and milk, correct diagnosis may be difficult: if he further states that the fruit consisted of green apples, the case becomes clearer. If this were to be a complete analogy, the patient would

first mention that he had always had a weak stomach, was accustomed to frequent smoking, and had had an appendectomy the previous year. The latter facts are misleading, and the subject brings them forth because he himself thinks that they are the only factors having any direct bearing on his present disorder. Solution of a problem of this type is difficult if relevant facts are not brought to light.

Here the analogy ends, for it is usually unnecessary for the doctor to explain why he believes the apples to be the cause of the trouble. When, and if, further data are obtained on a quality control problem, the industrialist or engineer naturally wants to know how the source of variation has been identified. If the data have been properly obtained, let us say by means of a factorial experiment, it is ordinarily not difficult to demonstrate the manner of identification—even when a correlation effect of two or more factors is the only significant variable. Should the data have been obtained in some hit-or-miss fashion, however, the methods of analysis are likely to become more involved, the answer less reliable, and the explanation may consequently be more lengthy: the importance of acquainting engineers with appropriately planned methods of statistical investigation cannot be over-emphasized. The use of designed investigation of quality control factors has only in recent years increased in this country to an appreciable proportion, following the development of the statistical background in this field. To take advantage of the analogy already employed, the designed statistical experiment is very similar to that instituted in modern clinics, in which many possible sources of trouble are included in the examination. From the picture obtained at a given time, quantitative conclusions are drawn concerning all factors considered.

In order that the two points of view—the engineering approach and statistical methods—might be brought together for engineers already familiar with industrial methods, the Massachusetts Institute of Technology has been presenting a summer course in Industrial Statistics: a description of the subject is included with the other exhibits. Necessarily concentrated into the short period of two weeks to accommodate those attending, the subject matter represents the crystallization of several practical statistical applications. It was believed advisable to limit the enrollment to approximately twenty students, in order to avoid the confusion likely to be had with a larger class. The results have been gratifying, and have been due primarily to the demonstration of practical control problems and the statistical methods of solving them. In order that those taking the course have the opportunity to accustom themselves to the aspects of industrial statistics, a standard work on

basic quality control is suggested as advisable preliminary reading. Neither this, nor any of the courses previously mentioned, is intended for instruction in pure mathematical statistics. That function is estimably performed at several universities, notably Princeton University.

Engineers studying industrial statistics ordinarily find it difficult to visualize the mechanics employed in quality control work and in industrial experimentation. When the mathematical principles behind such work can be illustrated by means of exemplary cases, it has been found that the principles themselves are more apt to be absorbed. A further aid to understanding is found in the large proportion of time set aside for individual classwork on representative problems, including computation. This so-called laboratory period each day relates the less tangible aspects of control analysis to the practical procedure, and therefore tends to crystallize the conceptions underlying statistical theory.

The students of the summer course have been diversified, both in field and in experience. Although all but a few have been engaged in some line of manufacturing, the products represented are so varied that some difficulty has been experienced in finding material of common interest. To avoid stagnation of interest, and to add to the experience of others with similar problems, the suggestion is made in advance of the course that each engineer bring with him any control problems which are typical of his field. This action has not only served its purpose during the course, but has also paved the way for further contacts between the members of the staff and the companies represented, by providing a basis of mutual understanding. In several cases, engineers who have brought to the session illustrative examples of their problems in quality control, have extended the acquaintance with intermittent correspondence on further cases of interest. Still others have been able to return and discuss current work and progress in greater detail.

Each of the courses mentioned, in retrospect, serves the purpose of reconciling statistical with engineering methods in the common field of quality control and industrial experimentation. Of all three, the first and last courses are perhaps the most important, since they give specialized training to those who are most likely to use it in improving quality control.

ENGINEERING APTITUDES: THEIR DEFINITION, MEASUREMENT, AND USE*

(A Description of the Work Done by a $26,000 W.P.A. Project at Missouri School of Mines, 1938 to 1941)

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In Retrospect

It is something like twenty-three years since the memorable *"Army Alpha"* tests were administered to personnel of the United States Army during the first World War. It was then that the country learned that, of all those tested, the Engineer Officer (including many civil and mechanical engineers) ranked at the very top.

It is twenty-two years since this Society, highly impressed with the possibilities of psychological testing of engineering recruits, utilizing tests like the Army tests, sponsored administration of L. L. Thurstone's battery of psychological and aptitude tests. Correlation coefficients between test scores and scholastic achievement ranging between 0.29 and 0.56 were secured from the scored papers of some 7,000 engineering students.

It is eighteen years since Dean Carl E. Seashore recommended to this Society a trial of the then new *Iowa Placement Tests,* devised by Geo. D. Stoddard and associates, as a basis for the selection of entering students, and their segregation for better instructional purposes into *ability groups,* high and low. It is sixteen years since this Society first sponsored administration of the Iowa tests, and fifteen since William E. Wickenden and the Board of Investigation and Coördination, in a comprehensive outline, proposed further and continued experimentation along these lines by the one hundred and fifty odd engineering colleges of this country.

It is now fourteen years since the present writer first wrote an objective engineering aptitude test, and thirteen years since he and Dean Focke, of Case School of Applied Science, presented papers before the general session of this Society at the Chapel Hill meet-

* Paper presented at the 49th Annual Meeting of S. P. E. E., Ann Arbor, Mich., June 27, 1941.

ing, in North Carolina. Those papers showed that correlation coefficients between the "Iowa" and "Mann" placement tests and first year scholarship ran as high as 0.70. This figure represented a very distinct advance in the writing and use of aptitude tests, and indicates the progress made during this Society's first ten years of experimentation.

From a situation where, only twenty-five years ago, no engineering college was interested in administering any aptitude test at all—knew of none—we have now come so far along this road that, in a report read by the writer five years ago, before a conference of this Society at Madison, it was shown that out of ninety-four engineering colleges which had replied, seventy-four, *or nearly eighty per cent,* had by 1936 adopted *at least some one* such aptitude test for use in its regular program.

Many of these colleges were using Iowa Placement Tests, American Council (Thurstone) or Ohio (Toops) psychological tests, Manntests, Coöperative Tests, or various others. Fifty of these colleges were then using such test results for vocational counseling, twenty-five for prediction of graduation of its entering students, six for selective admission, five for diagnosis and remedial purposes, and thirty-one for other purposes. In the State of Iowa, some three hundred thousand Iowa Every Pupil Tests are now given each year. A total of 1,013,194 of the Iowa Placement Tests were distributed between 1927 and 1936, and a total of 153,672 *Coöperative* Tests were sold for the one year, July 1, 1935, to March 1, 1936. This record indeed spells marked progress along such lines.

Qualities Wanted in the Engineer

We have come to the point where we can raise the question, "What qualities are wanted in the Engineer, and which of them can be objectively measured?" Engineering philosophical literature is full of descriptions of the ideal engineer and his qualities. Probably no one engineer was ever invested with all the qualities that have so been specified. It has been said that the engineer must be ingenious, apt in acquisition of knowledge, a good writer, a skillful draftsman, expert at figures, versed in science, acquainted with history, informed on natural and moral philosophy, above meanness, not arrogant, just, faithful to his employer, not avaricious, dignified, of good character, and well grounded in the first principles of his profession.

These specifications, written twenty years before the time of Christ, and by Vitruvius, are not greatly different from modern specifications, a sample of which requires the ideal engineer to have interest in his work, will power, adaptability, leadership, personal-

ity, initiative, industry, general ability, special abilities, desire to know fundamental principles—in particular the laws of nature—; accuracy of thought, excellent moral standards, high ideals, self discipline, good judgment, an analytical mind, interest in the abstract, interest in the difficult, an acquisitive mind, enjoyment in working with inanimate things, originality of thought, power to see a thing before it exists (ability to visualize), ability to see a need and the remedy before the need arises. Modern specifications stress interest and ability in the *tool subjects* of engineering, such as general sciences, mathematics, drawing, physics, chemistry; the ability to visualize; and curiosity in respect to the *how and why* of things.

Engineering Aptitude a Composite Quality

One of the difficulties facing those who would work in the field of selection of students who are about to enter college is the lack of a satisfactory notion of engineering aptitude. Engineering educators seem to believe that there exists some specific measurable mental trait or traits, which the engineer has and which those who are not engineers do not have—in other words, that engineers are *born,* not *made.*

As a matter of fact, there are probably few human traits to be found in absolutely zero amount in any individual. The more useful and scientific concept is that these various qualities exist in individual human beings in different degree—one quality in low degree, another in medium degree, and a third in high degree—exactly as we find various chemical elements existing in differing amounts in different chemical compounds. What we need to have and to apply is a comprehensive group of human yardsticks (tests) that will enable us objectively and accurately to measure or to estimate the *relative degree* in which each of the measurable qualities exists in any one individual.

In addition to whatever other aptitudes the prospective engineer of the future must possess, it seems evident that he must have at his disposal all those aptitudes which are necessary to enable him satisfactorily to complete a standard four-year course of engineering study or its equivalent. This being true, then we already have at our command, in the Iowa Placement Tests, in the Manntests, and in the Iowa High School Content Test and the Coöperative Tests, a series of relatively accurate engineering aptitude tests which can at once be made use of in every engineering college in the country. Although the "Coöperative" series of tests has not been experimented with in precisely the same way that the Iowa tests have, yet the results achieved with them, where they have been employed, should mean that they could be used with as much effectiveness, per-

haps, as the Iowa tests. The "Physics" tests in this series has been widely used and validated.

Eminent engineers from time to time have invested the ideal engineer with such qualities as honesty, accuracy, integrity, character, power to visualize, and interest in engineering. But for the present let us be satisfied to limit our definition of engineering aptitude so that it will include only those qualities which are *objectively measurable.* Of course, as time goes on we shall find it possible thus to measure more and more of the qualities we desire the engineer to have.

What Kinds of Tests Shall be Used To Measure Engineering Aptitude?

This question has been raised before, but again has been brought to the front by the work done on the project being described. The question is also raised as to just *how* effective, are the several types of tests so far used.

To date, one of the major objectives in use of such tests has been *to select the entering student*—perhaps in advance of his actual entrance to the engineering college—and *to predict whether or not the student can or will graduate* at the end of his four years in the engineering college. In some quarters disappointment has been voiced because such *scholastic aptitude tests* as have been used have failed to produce 100 per cent correlation when compared with scholastic achievement and graduation. Such a demand on *scholastic* aptitude tests would be quite unscientific and unfair. Should correlations as high as 0.70 be secured by use of such tests—and such correlations *have* been secured—that is in all probability as high as the purposes for which such tests are used would at all require. In other words, the *scholastic* aptitude tests now available represent valid, satisfactory working instruments.

In order to be convinced that scholastic aptitude tests are but one of the several types of tests needed to adequately measure the entering students, or raw recruits for the engineering profession, it is only necessary to point out *a few of the many other qualities* possessed by the entering students, which in their turn, and also, heavily condition the student's progress in the engineering college. Among these other factors are such things as (1) physical fitness, bodily vigor, *health* (present studies show that as high as 1 per cent of the entering class at the Missouri School of Mines is eliminated from engineering study and practice at the end of four years by permanent impairment of health, or by accidental death); (2) Attitude toward work of the curriculum—and perhaps this includes also mutual attitude, of student and teacher; (3) Home

conditions, pleasant or discordant; (4) Financial resources, or necessity of augmenting them by working while in college; (5) Extra-curricular activities in general; (6) Personal character and appearance, degree of extrovertness or introvertness; (7) Personal idiosyncrasies; (8) Interest in things that detract from study, including interest in *girls;* and (9) Interest in the particular phase of engineering study being pursued (professional interest).

As we have pointed out before, the modern scholastic aptitude test satisfactorily measures *mental ability* and *preparedness* in the fundamental scientific and humanistic *content courses.* E. K. Strong's Vocational Interest Test, so interestingly presented to this Society at last year's general session at Berkeley, also and very satisfactorily measures the general *profesisonal* and *subject-matter interests* of the students (and other persons) tested, as our own studies under this Project amply demonstrate.

Just as a suggestion, we may write an equation which in a most general way indicates the complex nature of the problem of adequately testing a human being, and indicates also just how far we have progressed in making such measurements satisfactorily. The equation is:

Health + Finances + Attitude + Home Conditions + Extra-curricular Activities + Extrovertness or Introvertness + Personal idiosyncrasies + Interest in *girls* or other things that detract from study + Professional Interests + Scholastic aptitude, *are equal* to SUCCESS, which we may define as scholastic achievement and graduation from the engineering college, and successful entry into engineering practice.

Of these ten "aptitude" categories, this Society has in the main been interested only in the last on the left hand side of this equation. All our eggs have been concentrated in this one basket, so to speak. Although fairly satisfactory tests have been devised to measure some of the other qualities indicated, little or no use has been made of them in such ways. There is a need both for objective tests in the several other fields so indicated, and for ready means of comparing or correlating results of such tests with the results of the scholastic aptitude tests.

PERSONOGRAPHS—A GRAPHIC SUBSTITUTE FOR MATHEMATICAL CORRELATIONS

As students in the grade schools we were taught that figures relating to pears and apples could not be indiscriminately mixed. And so it is in this present field of testing. Numerical correlation coefficients and regression equations cannot be utilized to express

accurate relationships between test scores in any two of these fields. If the problem were to be so analyzed mathematically, we should be in that type of tangle we meet when, in passing over a range of "X" values, we encounter ten regions or areas of discontinuity for "Y." The need for proper correlating procedures, for the single individual, and for group studies, is not furnished by any mathematical correlation coefficients or regression equations so far devised.

To meet such a need, the writer has devised and the staff has used in this Project, a chart which he calls the *Personograph*. This can be constructed either in rectangular or polar form, as illustrated by the accompanying chart (Fig. 1). These *personographs* are, in fact, "maps" of the interests, potential scholastic ability, mentality, personality, scholarship, and other attributes of the person so measured. They bridge the gap of *discontinuity* which mathematical correlation coefficients and regression equations have not yet crossed, and present all the test data in such a form as permits a very quick and simple appraisal of the whole individual mental and physical make-up, so far as it has been measured. The further description of such charts is taken from an article by the writer which appeared in *Civil Engineering* for September, 1936 (pages 581–584 inclusive).

In order to construct charts of this kind, some rapid, practical, and convenient method of converting raw test scores into comparable standard measures is necessary. To meet these special needs the writer devised a system of vigintile (twentieth) scores ("V-scores" for short) which has proved to be exceedingly flexible, convenient, and useful in the program described. If raw scores on any test are sufficiently well distributed, it is possible very quickly to select those students whose scores place them in the top twentieth on a given test. In our system this top twentieth is numbered "one," "01," or "V_1." In like manner students in the lowest twentieth may be selected, that is, in "twenty," or "20," or "V_{20}."

These "V-scores," being readily understood, are very convenient if one desires to correlate the scores on two or more tests. In practice, the V-scores, or twentieths of the class, are very readily determined from a high to low tabulation of the scores and student names on any given test. If, for example, there are 200 students in a freshman class, there will be ten students in each of the twentieths. These groups of ten may be rapidly separated on the list by drawing pencil lines between successive groups.

The "personograph," Fig. 1 (see page 678), devised by the writer, provides a means of showing on a single polar chart all the

measured qualities of the individual student, including mental abilities, special abilities, personnel ratings, term-by-term scholastic records, and intensity and diversity of professional interests. Each small sector of the chart is reserved for a single test or some one measurement made. High ability is indicated if the individual test sector is completely shaded from inner to outer zone. Low

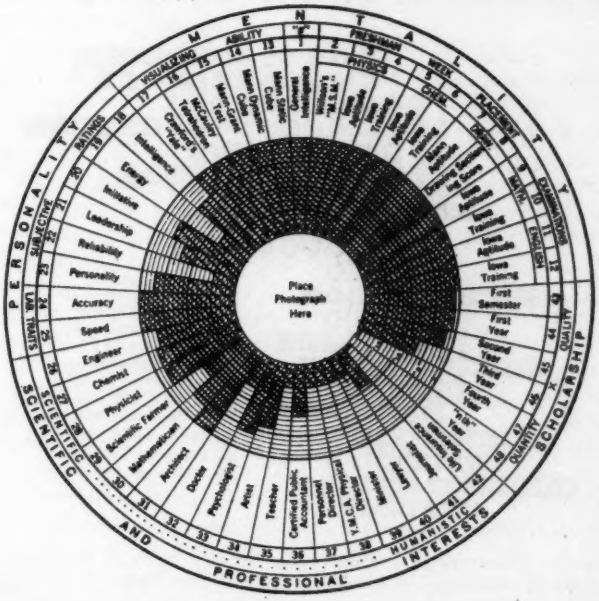

FIG. 1. Polar Personograph of a High Grade Engineering Student. Missouri School of Mines; Curriculum, M.E.; Class of 1934; Student No. 34160.

ability is shown whenever sectors are only partially shaded, starting from zones nearest the center of the chart.

Using such zones on the chart, it is possible to record in what twentieth the student should be classified in each test or measurement made; and one can also see to what quarter of the class, or other division, he belongs. Student 34160, shown in Fig. 1, had high mental ability, high powers of visualization, a good scholastic record, and high interest in scientific and engineering fields. His interest in the humanistic fields, like that of many practicing engineers, was relatively low.

Tests Prove Efficient and Valuable

The use that can be made of such a testing program in predicting graduation from an engineering course after four years of engineering study is suggested by Fig. 2. The tests were given at the time of entrance to the engineering college, before students had been in any classes. Students in the top horizontal row of the chart are those who rated in the top twentieth of the group taking

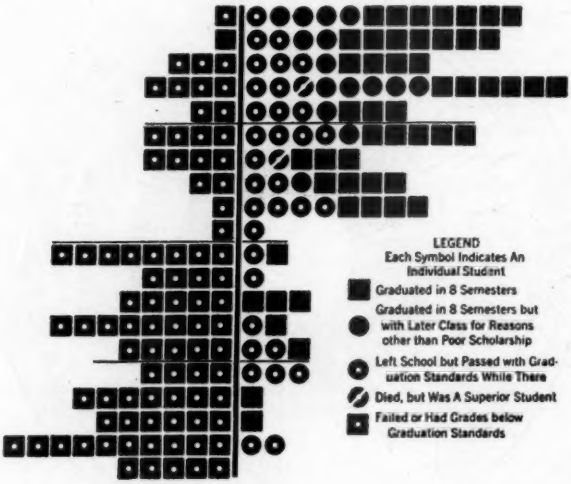
LEGEND
Each Symbol Indicates An Individual Student
Graduated in 8 Semesters
Graduated in 8 Semesters but with Later Class for Reasons other than Poor Scholarship
Left School but Passed with Graduation Standards While There
Died, but Was A Superior Student
Failed or Had Grades below Graduation Standards

Fig. 2. Effectiveness of Engineering Drawing Aptitude Placement Test in Predicting Graduation in Engineering Curricula After Four Years of Study.

the Mann Drawing Aptitude Test during freshman week, the fall of 1935. The bottom horizontal row has in it all students who rated in the lowest twentieth on the same test. Students in intermediate horizontal rows rated in the intermediate twentieths on the test. The V-score norms used in this chart were determined by combining the scores of all students who took the tests in the fall of 1931 and 1932. This will explain the inequality of the number of students appearing in the various horizontal rows, or twentieths.

Full squares on the chart represent individual students who graduated regularly in eight semesters. Full circles are for students who did not graduate with their own groups, but had either already graduated, or would graduate the following May, all in

their own individual eight-semester periods, although delayed for financial reasons or for causes other than poor scholarship. Hollow circles are for students who are out of school, but who passed their work with or above graduation standards while they were there. Two split hollow circles are for superior students who died. Hollow squares to the left of the vertical line are for students who either failed or had grades below graduation standards. Most such students have left school.

On the basis stated, all the students to the left of the heavy vertical line are to be rated as scholastic failures in this institution. Those to the right of the vertical line, excepting the two who died, are scholastic successes. Students who had transferred to this school from other schools, who did not take the placement tests, are not included in the chart. A survey now in progress will enable us to show on this same chart those of the graduates for the past ten years who have entered the profession and achieved success.

Inspection of the chart, Fig. 2, shows among other things the following: (1) Of the group considered, 84 per cent of all students graduated regularly were from the top half of the class as selected by the Drawing Aptitude test; (2) all students not yet graduated, but nearing graduation (or already graduated but not with their own group) are likewise in the top half of the class as set up by the test; (3) 53 per cent of all graduates came from the upper quarter of the class; (4) 77 per cent of the lower half of the class were scholastic failures; (5) 74 per cent of all failures for the entire class came from the lower half of the class; (6) two exceptional students (1 per cent of the class, who undoubtedly would have graduated had they lived) died.

The writer has constructed similar charts for each separate test of the Iowa series used, and for pooled scores on all the tests. Sets of charts of the kind covering fourteen years of study, and particularly for the last six successive graduating classes, exhibit practically the same effectiveness for the tests. We think the charts and these studies show that a pre-college selection of superior students adapted to succeed in engineering study is altogether possible at this time, and that the "Manntests," the Iowa Placement Tests, and the Iowa High School Content Test, supplemented by the Strong Vocational Interest Test, form a valid basis for such selection. The "Coöperative Tests" could without doubt be used just as effectively if desired. Furthermore, qualities measured by many other available objective tests could be added to the charts we have shown, provided that raw scores on such tests permit conversion into the V-score system we have used.

Detailed Procedures Followed on Project

The procedures followed by the working staff on the project are about as follows: The project supervisor contacts the superintendent of the school system or the personnel director in the college where it is desired to administer the tests. A mutually agreeable date for administration of the tests is selected, and on that date the writer or special assistants go to the institution and administer the tests.

In order to minimize the cost of tests, the writer has prepared special answer sheets, both for the Iowa High School Content Test and for Strong's Vocational Interest Test. The use of such answer blanks, which cost $1.50 per hundred copies, makes unnecessary marking up and destruction of the expensive test folders, which are furnished by the publishers of these two tests.

The answer sheet for the High School Content Test consists of a series of "grids," the squares of which measure 1/6th of an inch on a side. The five squares of the grid running horizontally take care of the "five choice" answers the student must make, and the grids have enough squares running vertically to take care of the total number of questions in the test. In answering any one question the student places a pencil mark within that square (1st, 2nd, 3rd, 4th, 5th) which indicates his answer.

In scoring these sheets, some 35 or 40 student papers are placed in a cork bottom box, the sides of which closely fit the printed forms. A properly marked copy or key is placed on top of the pile. Using a shoemaker's awl, the entire pile of papers is punctured in those squares in which the correct answer appears on the key. This simple procedure quickly "keys" each individual paper. Each separate paper is now scanned, and the number of right responses recorded. The student's "raw" score, together with his "V" score, as previously explained, are determined from accurate "norm" tables which have been built up since the project started.

The answer blank devised for the "Strong" test contains a series of circles in certain of which the person tested places a pencil dot, instead of encircling the letter "L I D" as required when the test folders themselves are used. When these answer blanks come to the project work room, the staff proceeds to punch out each circle wherein the person tested placed a dot.

To score the Strong test, this punched answer blank is now placed in turn upon a series of seventeen (17) similar answer sheets to which numbers found on Dr. Strong's keys have been transferred. There is such a key for each occupation for which Dr. Strong has devised one. The seventeen keys being employed

on this project include those for Engineer, Chemist, Physicist, Scientific Farmer, Mathematician, Architect, Doctor, Psychologist, Artist, Teacher, Certified Public Accountant, Personnel Manager, Y. M. C. A. Physical Director, Minister, Lawyer, Journalist and Life Insurance Salesman.

On these keys the numbers, which on Dr. Strong's keys are marked as positive, appear in black. The negative numbers are made to appear in red. In scoring this blank the staff worker places the punched answer blank for any individual successively and in turn upon each of the seventeen keys. He then counts and adds mentally in order to procure the sum of all the black numbers which appear through the punched holes. Likewise he finds the sum of all the red numbers. The difference provides the score, and when this is obtained, the corresponding "V" score (or "20th") is taken from an appropriate table of "norms."

The "V" scores for both the Iowa High School Content Test and the Strong Test are now entered upon the Personograph, size $8\frac{1}{2}'' \times 11''$, in a space provided therefor, following which the "V" scores are used in shading in or plotting the data on the personograph. This completes the procedure for obtaining a personograph for any one person.

The data taken from each individual test blank is also recorded on a series of $3'' \times 5''$ cards. These are utilized in making comprehensive distribution charts which are used as the basis for construction of new norm tables. Such charts, when made up separately for students in the high school group and students in the college groups which have been tested, very clearly exhibit many interesting group differences (or differences in reaction to the test in general) as between the high school and the college groups.

For instance, when such charts for high school groups located in St. Louis and in western and southern Missouri were compared, it became clearly evident that the St. Louis high school groups had in them a far greater proportion of students whose primary interests were in the scientific and engineering fields than did the western or southern Missouri groups. The southern group had in it an exceptionally large number of students whose interest seemed to lie in the fields of religion or missionary work or ministry or teaching, rather than in scientific fields. One of the western groups indicated very clearly the predominance of interest in commerce and business. From these data it would seem that the interest of high school students is conditioned in large upon the general character of the community in which they live, and the type of industry and other activity carried on in the region.

Lastly, students who have been measured by the methods de-

scribed are granted free access to their individual project records, and most students seem to find the charts of considerable use and interest. Many desire to have, and are given, copies of their personographs to aid them in deciding whether or not to continue in engineering study; what branch to elect if they remain in engineering; and what professional field to enter if they decide they are out of place in engineering. Each student may have, if he so desires, the counsel of the Project Superintendent.

In conclusion, the question may be asked, "Of what value has this W. P. A. Project been in furthering the researches being made respecting engineering aptitude and its measurement? First, it has been shown that such aptitude tests can be successfully given in heterogeneous groups of high school and college students. It is possible with fair accuracy to choose those students who should follow technical engineering study, and those who should not. The non-technical student can be directed to those general fields of study and activity for which the tests show he is better adapted. While the student can be so *advised,* the *final choice must be left to him.* The *scholastic* aptitude tests now in use *at the college entrance level* should not be given to students below the junior year in high school, as these lower classes have not yet had physics or chemistry, sections on which are highly important and are usually included in the present college scholastic aptitude tests.

An even greater advantage accrues to the senior high school student who is just about to graduate and make his choice of college and life work. From norm tables which this Project has assembled, and from charts such as we have presented, the graduating high school student and his advisers can with fairly definite assurance ascertain what probable chance the student has of success in the engineering college, and what his predominant professional interests are. *The final decision is to be left to the student,* if democratic methods in education are to prevail.

In one instance, following procedures such as have been described in this paper, a class of 250 entering freshmen at Missouri School of Mines was given a battery of four aptitude tests—the Iowa High School Content Test, Strong's Vocational Interest Test, Mann's Drawing Aptitude Test, and Mann's Mutilated Cubes Test of Power to Visualize. With the assistance of our W. P. A. Project all the papers for this group were completely scored, the results plotted on personograph cards, and the student's photograph pasted in place. *The entire set of cards was so completed before any of the students appeared in any of their classes.* In fact, those classes sectioned on the basis of ability were made up on the basis of the cards so prepared. When the difficulty and time for scoring the

Strong Test is taken into account, we feel that this achievement is one that has *never before been achieved in any college anywhere.*

One final benefit to the student so tested must certainly accrue to him from his own inspection of the results, plotted on the personograph. He may feel and contend that the tests taken *do not measure his abilities or his interests at all accurately.* We have had that reaction. In such a case, it is probable that the greatest benefit the student received is that of being forced, for once in his life, to seriously face the question of his relative abilities, and his professional interest when compared with that of others. If no other result were to be obtained from the testing program, this one result would be worth a very great deal to the student, personally.

During the time this Project has been in operation, some 10,000 strong "Interest" Tests, and some 5,000 Iowa High School Content Tests have been given. Literally hundreds of persons—including students, professors, teachers in grade and high schools, and persons out of a job, intent upon finding the "one and only" occupation they should follow—have applied at the Project Office for permission to take the tests, and for the test data finally secured. Not the least of the work done by the Project has been in trying to interpret correctly for such persons the data shown on their personographs. Students desiring copies of their Personographs have been furnished the same for a charge of five cents—enough to cover the cost of the actual material handed out. Such service, given elsewhere, has cost the client $10.00.

A Missouri School of Mines Bulletin is being prepared which, when finished, sometime this fall, will contain a more detailed discussion of the work of this Project, together with full tables of data, correlation coefficients, and sampling of personograph charts.

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THERMODYNAMICS FOR UNDERGRADUATE CHEMICAL ENGINEERS *

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Thermodynamics, according to Webster, is the science which deals with the inter-transformation of heat and work. To the average chemical engineering teacher of this subject faced with the transformation of a little knowledge into the student's ability to do work, it assumes different proportions. The undergraduate chemical engineer having just completed a course in mechanical thermodynamics dealing only with the energy forms TS and PV soon finds that the introduction of other intensive-extensive factors "puts him out on a limb" which is so new or so strange that unless he can apply the work immediately the entire purpose of the course is lost and undergraduate thermodynamics immediately becomes just one of those requirements for a degree.

Practically all who are faced with this problem agree that instruction in thermodynamics is a matter of repetition. Facility in the use of this science only comes with use and the undergraduate is, perhaps, in the most unfortunate position of all. Mechanical thermodynamics is most readily apparent and as a result is rather easily grasped. In order to promote the use of the principles involved, the approach in our program has been to coördinate thermodynamic instruction with other service courses, chemical engineering courses, and even inspection trips. In this method success of instruction has been obtained—at least it is believed to be so. To the instructor a profound sincere interest, a desire to work, and readiness in response on the part of the students are the most indicative barometers of successful instruction; these and ability in problem work. To engender these mild successes in the midst of the basic chemical engineering courses is not an easy task, for many fields must be covered.

Chemical Thermodynamics; Its Scope

For the purposes of definition let it be said that chemical thermodynamics involves a consideration of all the energy states or transformations that a system may encompass or undergo.

* Presented at the 49th annual meeting, S. P. E. E., (Chemical) University of Michigan, June 23–27, 1941.

In essence it deals with applications of the *three* laws of thermodynamics. The first law, insofar as chemical engineers are concerned, must cover with reference to the system a consideration of the terms involving *T-S*, *P-V*, voltage-equivalents, surface tension —surface, osmotic pressure—system content, chemical potential—mols, etc. The emphasis should be on the "and so forth" in order that the student's mind may be willing to accept any new types of energy that may be thrust upon him in problem work.

It should be noted that entropy as the extensive property of heat energy is first introduced to the student in the first law work. This follows the method used by Professor G. G. Brown. Inter transformations of all or any of these energy forms are considered.

In the second law the possible transformation extent of heat into work and the further aspects of entropy as they affect chemical equilibrium are considered. The implications of the thermodynamic temperature scale are dealt with. The third law permits a direct determination of the extent of a chemical transformation from purely thermal data.

This in very brief outline indicates the scope of the thermodynamics as taught to undergraduate chemical engineers. What, may be asked, is the instructional method employed to cover these aspects?

Approach to the Undergraduate Problem

Introduction

Our approach to the teaching problem has been largely a matter of coördinating the work as much as possible with other engineering courses and also placing the student immediately in a heuristic system. The student when received has had calculus and thermodynamics for mechanical engineers. He is taking unit operations, physical chemistry and chemical technology. To create confidence at the outset a rather extensive review of calculus is given; however, the student must make it work. In large measure the student must make his own derivations to suit the particular thermodynamic problem. Calculus is intended to be a powerful tool, and as such is used extensively to the benefit of both this course and his mathematical thought processes. Constant practice is obtained by not grouping the derivations in the first term of the two utilized but by spreading them throughout. The response has been good. As an example, in a problem such as determination of the heat addition required to maintain an isothermal spray, the attack is somewhat as follows:

A. The process involves heat and surface extension, therefore, the internal energy increment involving these terms only is

$$dU = TdS + \gamma d\sigma.$$

(Only at this point is it necessary to use caution. The student will soon find that care must be taken to choose correctly the property which will give the appropriate derivative expressing the given data. If this is not done it is too easy to make the mistake of cross cancelling in products of partial derivatives. Why they do this at first I cannot say. With practice the error is soon conquered. Thus in this problem dU must immediately be transferred to dA.)

$$dA = dU - d(TS)$$

or

$$dA = \gamma d\sigma - SdT. \tag{1}$$

B. The dA increment may be developed as a complete differential in terms of the variables specified (T, σ)

$$dA = \left(\frac{\partial A}{\partial \sigma}\right)_T d\sigma + \left(\frac{\partial A}{\partial T}\right)_\sigma dT. \tag{2}$$

C. By *comparison* of (1) and (2) it can be noted that the coefficients may be equated:

$$\gamma = \left(\frac{\partial A}{\partial \sigma}\right)_T,$$

$$-S = \left(\frac{\partial A}{\partial T}\right)_\sigma.$$

D. The second cross partial derivatives are equal by the usual rule, therefore:

$$\left(\frac{\partial \gamma}{\partial T}\right)_\sigma = -\left(\frac{\partial S}{\partial \sigma}\right)_T.$$

E. Multiplying through by T, splitting the derivatives, and integrating for a given surface creation gives:

$$-q_{rev\ T} = -T\Delta S = T\Delta\sigma\left(\frac{\partial \gamma}{\partial T}\right)_\sigma.$$

With given surface tension-temperature data the computations are straightforward.

The process of coefficient comparison used has proved to be a valuable device. The usual Euler criterion of integrability is not introduced as it is deemed too confusing. It should also be noted that the dG property or summation of net availability from transfer of extensive factors through a fall of intensity gives the same results (*i.e.* the equality of second cross partial derivatives of the two considered terms). It is believed that the illustrated comparison method is far more easily grasped. The student has proved

perfectly able to derive the Gibbs-Helmholtz equation, the four customary Maxwells (including the Clausius-Clapeyron), and other necessary derivations quickly, concisely, and without trusting to memory which often proves faulty.

Course Content

It has been indicated already that there is no sharp line of demarcation between derivation and application. There is a purpose for all derivations of an immediate practical sort. When the student is studying heat transfer he can understand the reason for "the fourth power" in radiation. Entropy increases as a measure of loss of available work can be used to interpret heat exchange. Direct comparison of heat exchangers, one operating with a narrow and one with a wide temperature difference, offer easy test of the concept and give a measure of efficiency. The idea of "heat pumping" is fully utilized. In passing it must be stated that the methods of Carnot in his original paper are far simpler and more easily understood than the confusing enhancements added since 1824 for discussion of the reversible heat engine.

Laboratory problems dealing with refrigeration as well as a local ice plant test are preceded by analysis of the coupled reversible engines. The simple derivation of a Mollier Chart for a refrigerant gas gives enlightening information on the use of thermodynamic relations and their practical application.

Chemical equilibrium is prepared for and dealt with in connection with chemical technology and physical chemistry. The timing with the latter is approximately correct, as a large amount of the theoretical background has been covered and direct applications can be covered from the engineering viewpoint. Repetition to allow better comprehension, however, is still practiced.

Various electro-chemical problems are computed. This year on our annual inspection trip we were fortunate in being able to visit a plant manufacturing sodium metal, electrolytically, in cells operating on an undisclosed voltage. The students, in order to make their reports complete, calculated the minimum voltage from thermal data. Also as a result of this trip, which included oil refining, interest was aroused in propane as a refrigerant. This material was made the subject of a Mollier Chart.

To cover distillation at about the same time as instruction in this subject is being given in the course in unit operations, the subject of solutions and enthalpy concentration charts is investigated. This leads to the use of Merkel charts and the Ponchon method. No great attempt is made to cover the derivation of these charts as it is believed that this would be too extensive for a two term course for undergraduates.

Summary

In general we have tried to indicate that in thermodynamics for undergraduate chemical engineers, the prime endeavor is to create confidence on the part of the student. Instead of making it abstruse, the entire subject is immediately integrated with courses that the student feels are "practical." With applications shown in these usable fields he is sure of himself and more important, sure of the use of thermodynamics in the associated fields. The undergraduate unequipped with all the basic engineering courses needs consideration if he is to cope with a reasonable course in this subject. By indicating the utility of the experience approach and total change aspects of thermodynamics that he has derived and put to work by himself, a new stronger faith in his basic engineering work is established for the student.

Outline of Two-Term Course in Thermodynamics for Undergraduate Chemical Engineers

First Term (10 Weeks)

I. Power Plant Cycles
- *A.* Steam generation.
- *B.* Engines.
- *C.* Turbines.
- *D.* Miscellaneous.
  1. Plant inspection.
  2. Plant analysis.
  3. Cycle analysis.

II. Review of Calculus
- *A.* Differential.
- *B.* Integral.
- *C.* Partial derivatives.
- *D.* Graphics.
  1. Integration.
  2. Differentiation.
- *E.* Data treatment.

III. Thermodynamics
- *A.* Scope.
- *B.* Definitions.
- *C.* Utility.
- *D.* Changes.
  1. The meaning of Delta.
  2. A property.
  3. Reversibility.

IV. The First Law

- *A.* The function ΔU.
- *B.* Proof of the property nature of ΔU.
- *C.* External aspect of ΔU.
- *D.* Internal partitioning of ΔU.
  1. Intensive factors: T, P, surface tension, chemical potential, voltage, etc.
  2. Extensive factors: S, V, surface, mols, equivalents, etc.

V. The Second Law

- *A.* Historical (Carnot).
- *B.* The three principles of Carnot.
- *C.* Thermodynamic temperature scale.
- *D.* Heat pumping.
- *E.* Refrigeration.
- *F.* Available work.
  1. Losses of available work.

VI. Thermodynamic Functions

- *A.* F, H, A (Define).
- *B.* Heat capacity.
  1. Entropy computations.
- *C.* Derivations, Maxwells.
- *D.* Meaning of properties.
- *E.* Miscellaneous derivations and problems.
- *F.* The utility of ΔF.
  1. Minus $\Delta F_{T,P,\text{rev}}$ = work other than PV type.
  2. Electrochemical.
- *G.* Van't Hoff Reaction box.
  1. ΔF as a measure of equilibrium.
  2. Fugacity.
     (*a*) Calculations.
     (*b*) Use.
- *H.* Influence of temperature on change of ΔF.
- *I.* Equilibrium calculations.

Second Term (9 Weeks)

VII. The Third Law

- *A.* Historical.
- *B.* Tie in with equilibrium calculations.
- *C.* Calculations.

VIII. Keenan's Availability

IX. Solutions

A. Partial molal quantities.
B. Relative enthalpy.
C. Use of enthalpy—concentration charts.

APPENDIX

A. Basis of Units

a) the international volt, ampere, and ohm
b) standard gravitational acceleration
c) legal definitions of mass and length
d) 1 international watt hour = 3600 int. joules

Units

(Define)	1 calorie/gram	= 1.8 B.T.U./pound
(Define)	1 Kw.H.	= 860,000 calories
	1 B.T.U.	= 251.996 calories
		= 778.26 foot-pounds
	1 Kw.H.	= 3412.75 B.T.U.
	1 Faraday	= 96,494 coulombs/gram equivalent
		= 41,492 B.T.U./volt, lb. equivalent
		= 23,051 cal./volt, gm. equivalent

Temperatures

a)	$t°$ F.	= 1.8 ($t°$ C.) + 32
b)	$T°$ R.	= $t°$ F. + 459.69

c) the international scale as defined

B. Problems

The following problems are a few taken from the course work and illustrate in general the type given to the students. Ability to work problems is the only safe index of grasp of the course content.

Derivations

1. Define q, w, ΔU, ΔH, ΔA, ΔF, S, and heat capacity.
Use mathematical definitions when necessary.
Which of these are complete differentials?

2. Define reversibility.
If a process is reversible, what is true relative to the energy quantities of system and surroundings? Show by equations.
What changes are made in the above expressions if the process is irreversible?
Define: (*a*) process, (*b*) cycle.
For a reversible cycle, what is true of the summation:

$$\Sigma \frac{q}{T}?$$

3. Show that

$$PV^{\frac{C_p}{C_v}} = \text{a constant}$$

for an ideal gas at constant entropy.

4. Derive a general expression for the Joule-Thomson coefficient

$$\mu = \left(\frac{\partial T}{\partial P}\right)_H.$$

Show that this is zero for an ideal gas.

5. Derive an expression for the reversible heat addition required in the creation of new liquid surface (*e.g.* in a spray) under isothermal conditions.

6. Derive the Maxwells (*P-V-T-S* type) starting from *F* and *A*. Using *A* and the general internal energy expression (system) involving only the effects of heat and electrical energy, derive an expression relating voltage, temperature, entropy, and reactant mols.

Explain in fifty words or less what it means.

7. A reversible heat engine is used to drive a reversible refrigeration machine. The engine takes in heat Q_1 at T_1 and rejects Q_2 at T_2. The refrigeration machine abstracts heat Q_4 from the cold source at T_4 and discharges this heat as Q_3 at T_3.

Derive a general expression for the ratio Q_4/Q_1 in terms of temperature only.

8. Maxwell predicted that for a radiant hollow body, the product PV was equal to one-third the contained or internal energy. From this and the Maxwell from *A* derive an expression for radiation pressure in terms of temperature. Show that this is also equivalent to the rate of radiation (Stefan-Boltzmann law).

9. In a liquid system involving only pressure and surface effects, derive an expression relating surface, volume, pressure, and surface tension.

10. From a hot body originally at temperature T_1 weighing M pounds and having heat capacity $C = a + bT$, heat is continuously abstracted in order to do work in a reversible heat engine rejecting heat at a constant sink temperature T_2. Derive an expression for the maximum work obtainable under these conditions.

11. Define fugacity. What is the use of fugacity in thermodynamic calculations?

Derive an expression for the fugacity/pressure for a gas with known compressibility ($Z = PV/RT$) factors.

Miscellaneous Process Problems

1. Two cylinders are connected by a pipe line with a valve. The cylinders contain nitrogen. This system is completely isolated. Cylinder I contains 1 mol of nitrogen at 200° C. and 50 atm. abs. pressure. Cylinder II contains 2 mols of nitrogen at 200° C. and 10 atm. abs. pressure. The gases are allowed to mix by opening the valve. What

is the entropy change? With what is this entropy change associated? (assume ideal gas).

2. Repeat the above problem but replace the nitrogen in cylinder II with oxygen at 200° C. and 10 atm. pressure. Ideal gases are to be assumed.

3. Compute the minimum work of separation of 1 lb. mol of oxygen from air (79 per cent nitrogen, 21 per cent oxygen) at 25° C. and 1 atm. abs. pressure.

4. A perfect gas is flowing in a pipe line. Its temperature is 20° C. and pressure is 30 atm. This gas expands through a valve to 1 atm. pressure. What is the entropy change per mol of gas?

5. The mol specific heat, C_p, of both helium and argon is 4.97 B.T.U./lb. mol, ° R. Given 1 lb. mol of helium at 1500° R. and 15 atm. pressure, and 2 lb. mols of argon at 150° R. and 3 atm. pressure, compute the final temperature of the throttle mixing of these two gases at 1 atm. pressure in an insulated chamber. What is the total entropy change for this process? (The gases are ideal.)

6. Two cylinders of equal size are connected by a valve and insulated from their surroundings. One is filled with 0.1 lb. mol of ideal gas at 2 atm. pressure and 100° F. The other cylinder is evacuated. Compute ΔU, ΔV, ΔP, w, q, ΔH, ΔS, ΔA, ΔF for the process taking place on opening the valve between the two cylinders. Is this process thermodynamically reversible? Why?

7. A cylinder is filled with 0.1 lb. mol of ideal gas at 2 atm. pressure and at 100° F. The surroundings are at 1 atm. and 100° F. A valve is opened and the gas is allowed to escape isothermally from the cylinder into the atmosphere. The gas originally in the cylinder is the system. Compute q, w, ΔU, ΔV, ΔP, ΔH, ΔS, ΔA, ΔF.

8. One lb. mol of an ideal gas is in a cylinder at 70° F. and 100 atm. pressure. This gas is expanded reversibly and isothermally through a perfect turbine to 1 atm. and 70° F.

a) Compute in B.T.U./lb. mol of gas the values of $\int PdV$ and w.

b) If the internal energy of an ideal gas is dependent solely on its temperature, compute q, $\int TdS$, and ΔS for this process.

9. The specific volume of liquid water at 212° F. is 0.0167 ft.^{3}/lb. The specific volume of saturated steam at 212° F. is 26.79 ft.^{3}/lb. The latent heat of evaporation of water to steam from and at 212° F. and 14.7 psi is 970.4 B.T.U./lb. Compute q, w, ΔU, ΔV, ΔS, ΔH, ΔA, ΔF, for the vaporization of one lb. of water from and at 212° F. and 14.7 psi pressure.

10. Ten lbs. of steam in a cylinder at 65 psi gage and 312° F. are allowed to expand isothermally into surrounding steam at 312° F. and under a constant pressure of 16 psi gage. From steam table data, compute w, q, ΔU, ΔV, ΔP, ΔS, ΔH, ΔA, ΔF.

11. 100 lbs. of steam at 400 psi abs. and 600° F. are expanded adiabatically through a throttle valve into an evacuated vessel. The total volume of the steam after expansion is 591 cubic feet, the absolute pressure is 100 psi, and the temperature is 550.7° F. The value of the enthalpy referred to liquid water at 32° F. for the original high pressure

steam is 1306.9 B.T.U./lb. The specific volume of the high pressure steam is 1.4740 cu. ft./lb. Calculate q, ΔP, ΔV, ΔU, ΔH, and w for this process.

12. Steam at a pressure of 100 psi abs. is in equilibrium with water at 327.8° F. and has properties as follows:

	Saturated Water		Saturated Steam		Superheated Steam at 400° F.
Pressure, psi abs.	14.7	100	14.7	100	100
Temperature, ° F.	212	327.8	212	327.8	400
Sp. Vol., cu. ft./lb.	0.0167	0.0177	26.8	4.426	4.934
Ht. of vapztn, B.T.U./lb.			970.4	888.2	
Enthalpy above 32° F. water	180	298.3			
Entropy above 32° F. water	0.3118	0.4742			

The average value for c_p for superheated steam at 100 psi abs. is 0.558 B.T.U./lb., ° F.

Calculate the values of q, w, ΔP, ΔV, ΔU, ΔH, ΔS for the process of evaporating 1 lb. of water (saturated) at 100 psi abs. and superheating to 400° F.

13. Hydrogen, oxygen, and solid sulfur are reacted to give liquid sulfuric acid. The heat liberated at 64° F. is 348,000 B.T.U./lb. mol at a constant pressure of 1 atm. Compute any of the following which are capable of being calculated for this process from the data given: q, w, ΔU, ΔH, ΔS, ΔF. This process is carried on in a constant volume calorimeter. The initial conditions are 1 atm. and 64° F. The final temperature is 64° F. What are the values of the functions calculated above?

Neglect liquid and solid volumes. 1 lb. mol of ideal gas at 1 atm. abs., 70° F. = 385 cu. ft.

14. The volume coefficient of expansion of mercury (mean 0° C. to 100° C., 1 atm.) is

$$\alpha = \frac{1}{V}\left(\frac{\partial V}{\partial T}\right)_P = 1.82 \times 10^{-4}/^\circ \text{ C.}$$

The compressibility coefficient is

$$\beta = -\frac{1}{V}\left(\frac{\partial V}{\partial P}\right)_T = 3.9 \times 10^{-6}/\text{atm.}$$

What pressure could be developed by heating mercury in a constant volume system from 0° C. to 20° C.?

15. Two pound mols of neon (mol C_p: 4.97) are in an insulated vessel at 5 atm. abs. and 700° K. In a similar vessel there are 1.5 mols of carbon monoxide (mol C_p: $6.60 + 1.20 \times 10^{-3}T$° K.) at 15 atm. abs. and 2000° K. What is the final temperature of the free adiabatic mixing of the two at 1 atm. abs. pressure?

What is the change in entropy for this process? (Both gases are ideal.)

16. A red hot rivet (1700° F.) weighing 0.8 lb. is dropped into a

bucket holding 0.75 lb. of snow and 15 lbs. of water. Compute the entropy change for this process.

Latent heat of fusion of ice = 144 B.T.U./lb.
Specific heat of steel = 0.11 B.T.U./lb., ° F.
Specific heat of water = 1.00 B.T.U./lb., ° F.

17. Kalustian's method for the calculation of injectors (Ref. Eng. *28*, 188, Oct. 1934) is based on the following equation:

$$\frac{W_1}{W_2} = \frac{H_d - H_c}{(H_a - H_b)(E_{ab})(E_{bi})(E_{cd}) - (H_d - H_c)}.$$

W_1 : motive or driving vapor weight,
W_2 : driven vapor weight,
H_a : initial enthalpy of motive vapor,
H_b : final enthalpy of motive vapor after isentropic expansion,
H_d : final enthalpy of driven vapor after isentropic compression from:
H_c : initial enthalpy of driven fluid,
E_{ab}: efficiency of expansion of motive vapor (usually 90 per cent on isentrop.),
E_{bi} : efficiency of entrainment of motive and driven vapors (usually about 65 per cent),
E_{cd} : efficiency of the diffusor section (usually 80 per cent).

Steam (90 per cent quality) from the last effect of a triple effect evaporator is at a pressure of 2″ Hg abs. Steam at 400 psi abs. and 100° F. superheat is available. The plant can use considerable steam at 10 psi gage. How much high pressure steam is necessary per pound of low pressure evaporator vapor in order to make this 10 psi gage steam?

What is the quality (per cent or superheat) of the final vapor?

18. The temperature-surface tension data for water are as follows:

Temp. ° K.....	273	293	313	333	353	373	393	413
S.T., dynes/cm.....	73.21	70.60	67.50	64.27	60.84	57.15	53.30	49.40

Present a curve for heat absorbed for atomization of water per square meter of surface created versus temperature. From the curve and with adiabatic conditions prevailing, calculate the temperature of water spraying from a nozzle fed with water at 30° C. The droplets average 0.1 mm. diameter.

19. Freon 12, CCl_2F_2, has properties as follows:

t° F.	P, psi abs.	$V_{liq.}$, cf./lb.	$V_{vap.}$, cf./lb.
0	23.87	0.0110	1.637
5	26.51	0.0111	1.485
10	29.35	0.0112	1.351
64	77.20	0.0120	0.540
78	95.85	0.0123	0.438
80	98.76	0.0123	0.425
84	104.8	0.0124	0.401

c_p vapor = 0.147 B.T.U./lb., ° F.,
c_s liquid = 0.22 B.T.U./lb., ° F.

For the liquid:

$$\left(\frac{\partial H}{\partial P}\right)_T = 0 \quad \text{(essentially)}$$

One pound of Freon 12 is circulating per minute in a simple refrigeration cycle. In outline the cycle is:

Gas leaves the compressor	170° F., 98.76 psi abs.
Liquid leaves the condenser	80° F., saturated
Valve expansion	true isenthalpic
Gas leaves cooler coils	20° F., 26.51 psi abs.
Gas enters the compressor	20° F., 26.51 psi abs.
Water for condenser	70° F. entrant, 78° F. exit.

Compute on a minute basis:
(1) The cooling water required for the condenser,
(2) The quality of the Freon after the expansion valve,
(3) The heat removed in the evaporator (cooler),
(4) The work input to the compressor assuming it is operating adiabatically.

Fugacity Calculations

1. The compressibility data for propane at 100° C. are:

P, atm.	1	5	10	20	30	40	50
Z	0.9916	0.9571	0.9137	0.8160	0.7001	0.5330	0.2250

Determine the fugacities at the pressures listed.

2. For sulfur dioxide, the van der Waals' equation is:

$$\left(P + \frac{6.8 \times 10^6}{V^2}\right)(V - 57.2) = 82.06T.$$

P in atm., V in ml., T in ° Kelvin.

Calculate the fugacity at 220° C. for a pressure of 150 atm.

3. Many thermodynamic data of the P-V-T type are reported in the form P_2V_2/P_1V_1 where

P_2 = actual pressure of the gas,
V_2 = actual volume of the gas at T_2 and P_2,
P_1 = base or comparison pressure,
V_1 = volume of the gas at P_1 and T_1, the comparison temperature.

For the calculation of fugacity, the Z data are usual, *i.e.*:

$$Z = P_2V_2/RT_2.$$

The terms are the same as those given above. T_2 is the actual temperature. Derive an expression allowing conversion of P_2V_2/P_1V_1 data to Z data.

For acetylene the comparison state is 70° F., 14.7 psi abs., 14.7 cu. ft./lb. (gas state).

At 100° F., these data are available:

P_2 in psi abs.

P_2	0	100	200	300	400	500	600	700	800	900	1000
$\frac{P_2V_2}{P_1V_1}$	229	221	211.9	202	191.5	179.9	166.3	150	129	77.8	56.1

Calculate the fugacities at the pressures listed.

Equilibrium Calculations

1. In the reaction (ideal gases assumed):

$$CO_2 = CO + \tfrac{1}{2}O_2$$

at 18° C.,

$$\Delta U = 67{,}331 \text{ cal./gm. mol.}$$

Compute the equilibrium partial pressure of the oxygen at 1800° C. and 1 atm. total pressure if the equilibrium partial pressure of oxygen at 1170° C. is 0.000125 atm.

$$R = 1.987 \text{ cal./gm. mol, } ^\circ \text{K.}$$
$$C_p \text{ for CO and } O_2 = 6.761 + 0.000606T + 0.13 \times 10^{-6}T^2,$$
$$C_p \text{ for } CO_2 = 7.713 + 0.0053T - 0.83 \times 10^{-6}T^2,$$
$$T = ^\circ \text{K.}$$

2. For the reaction

$$CaCO_3 = CaO + CO_2$$

equilibrium measurements of the CO_2 gave:

Partial Pressure CO_2 in mm. Hg	Temp. ° C.
0.11	500
2.35	600
25.3	700
168	800
373	850
773	900
1490	950
2710	1000

Compute q, w, ΔU, ΔH, ΔS, ΔA, ΔF, and T when one gram mol of $CaCO_3$ decomposes into CaO and CO_2 under equilibrium conditions to give CO_2 at a partial pressure of 75 mm. CO_2 may be assumed to be ideal under these conditions. The volumes of CaO and $CaCO_3$ are equal.

Electrochemistry

1. The vapor pressure of water in an acid solution is 0.02 atm. The temperature is 290° K. Hydrogen is liberated at the cathode in electrolysis of the solution at 1 atm. The oxygen is also produced at 1 atm. The E.M.F. for the electrolysis is − 1.23 volts. Determine K_p for the formation of water vapor from hydrogen and oxygen at 290° K.

2. At 1100° C. and 1 atm. total pressure, water vapor is 0.01 per cent dissociated into hydrogen and oxygen. The heat of formation of water vapor at 25° C. and 1 atm. from the elements is 58,500 cal./gm. mol. Heat capacity data are:

C_p for hydrogen and oxygen $= 6.5 + 0.001T$ cal./gm. mol, ° K.,
C_p for water vapor $= 8.81 - 0.002T$ cal./gm. mol, ° K.

Compute the minimum E.M.F. at 25° C. of a reversible cell liberating hydrogen at 0.5 atm. and oxygen at 1 atm. from an electrolyte in which the water vapor pressure is 0.02 atm.

3. Cadmium reacts with chlorine at 25° C. and 1 atm. to give cadmium chloride with the liberation of 93,000 cal./gm. mol. The heat of solution is negligible. In a plating bath with chlorine liberation at 1 atm., compute the total cost to plate out 100 lbs. of cadmium metal. Data as follows:

Energy efficiency of electrolysis (based on theoretical) = 55 per cent.
Energy cost: 1¢ per Kw.H.
Atomic weight of cadmium: 112.4.
Absolute entropies (25° C., 1 atm.) S, $CdCl_2$ = 31.5 cal./gm. mol, ° K.
S, Cl_2 = 53.31 cal./gm. mol, ° K.
S, Cd = 12.3 cal./gm. mol, ° K.

4. For the reaction:

$$Pb + 2HgCl \rightarrow PbCl_2 + 2Hg$$

a reaction voltage increase rate of 0.000145 volts per ° C. has been reported for the temperature 25° C. This is for potentiometric conditions.

Compute the reversible heat addition per mol of lead required for maintenance of the 25° C. isothermal reaction state.

5. When lead reacts with mercurous chloride at 25° C., a potential of 0.5357 volts is observed. This increases 0.000145 volt/° C. Compute the heat of reaction at 25° C.

6. In a constant volume bomb, sodium and chlorine react to give sodium chloride with the liberation of 97,810 cal. per gm. mol of sodium chloride formed at 25° C.

At 25° C., the absolute entropy data are:

NaCl = 17.3 cal./mol, ° K.,
Na(s) = 12.2,
Cl_2(g) = 53.31.

(*a*) Compute the minimum E.M.F. required to electrolyze NaCl to sodium and chlorine at 25° C. and 1 atm.

. . . . . .

Commercially the process is operated by use of a salt eutectic (sodium chloride-sodium carbonate) such that the effective bath temperature is 600° C. Chlorine is liberated at this temperature and 1 atm. pressure. The sodium is tapped at 600° C.

Sodium melts at 98° C. The latent heat of fusion is 31.7 cal./gm.

The latent heat of fusion of NaCl at its melting point, 804° C., is 7230 cal./gm. mol.

Heat capacity data are:

$$\begin{aligned} \text{Na(s)} &= 0.31 \text{ cal./gm., } ^\circ \text{C.,} \\ \text{Na(l)} &= 6.7 + 0.001T \text{ cal./gm. atom, } ^\circ \text{K.,} \\ \text{Cl}_2 &= 7.4 + 0.001T \text{ cal./gm. mol, } ^\circ \text{K.,} \\ \text{NaCl(s)} &= 12.8 \text{ cal./gm. mol, } ^\circ \text{K.} \end{aligned}$$

(*b*) Compute the minimum E.M.F. required to operate the process commercially.

7. For the reaction:

$$\text{Al}_2\text{O}_3 \rightarrow 2\text{Al} + 1.5\ \text{O}_2.$$

A. Compute the minimum E.M.F. required to manufacture aluminum at 950° C. with oxygen liberated at 1 atm.

Aluminum reacts with oxygen in a constant volume bomb to give 375,800 cal./gm. mol.

Heat capacity data:

$$\begin{aligned} \text{Al}_2\text{O}_3 &= 26.6 \text{ cals./gm. mol, } ^\circ \text{K.,} \\ \text{O}_2 &= 6.93 + 0.000188T, \\ \text{Al(s)} &= 5.23 + 0.00263T, \\ \text{Al(l)} &= 6.7. \end{aligned}$$

Aluminum melts at 657° C.; the heat of fusion is 2490 cal./gm. atom.

Absolute entropy data at 25° C.:

$$\begin{aligned} S, \text{Al} &= 6.82 \text{ cal./gm. atom, } ^\circ \text{K.,} \\ S, \text{O}_2 &= 48 \text{ cal./gm. mol, } ^\circ \text{K.,} \\ S, \text{Al}_2\text{O}_3 &= 12.8 \text{ cal./gm. mol, } ^\circ \text{K.} \end{aligned}$$

B. Commercially, carbon anodes are used and an equilibrium CO, CO_2 mixture is produced at 1 atm. Compute the minimum E.M.F. for this process at 950° C.

At 950° C.:

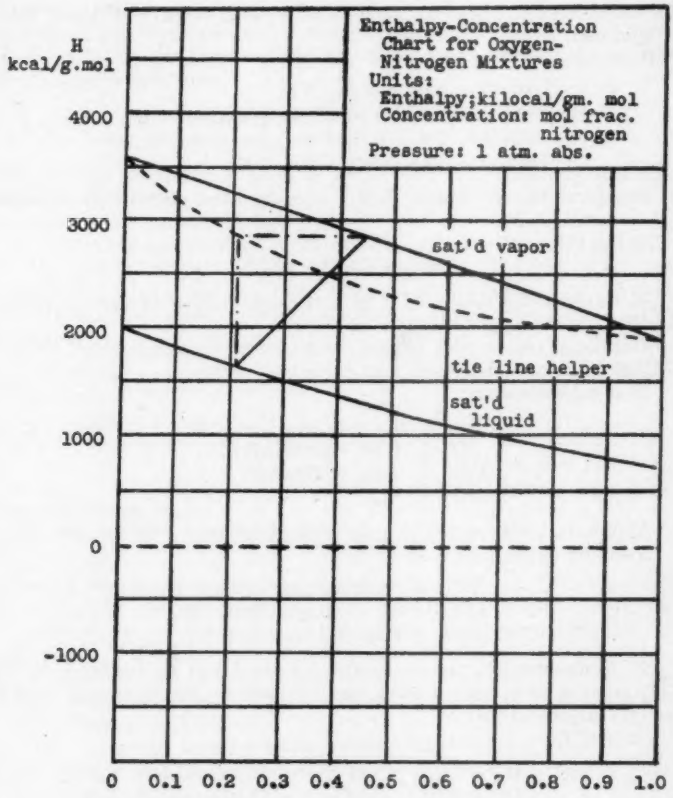
$$\begin{aligned} \text{C} + \text{O}_2 &\rightarrow \text{CO}_2, & \Delta F^\circ &= -91{,}582 \text{ cal./gm. mol,} \\ \text{C} + \text{CO}_2 &\rightarrow 2\text{CO}, & \Delta F^\circ &= -10{,}016 \text{ cal./gm. mol.} \end{aligned}$$

Solutions

1. For aqueous KCl solutions at 25° C., the molality (m): specific gravity data (d) are:

m	d
0	0.99707
0.1668	1.00490
0.2740	1.00980
0.3385	1.01271
0.6840	1.02797
0.9472	1.03927

Determine the partial molal volume of KCl at m values: 0.10, 0.30, 0.60, and 0.80.



Concentration: Mol fraction nitrogen in mix.

2. What heat is absorbed or evolved (state which) upon adding 15 mols of sulfuric acid to 10 mols of water at 1 atm., 18° C?

The relative partial molal enthalpies in aqueous sulfuric acid at 18° C. and 1 atm. are:

N_2 (acid mol fraction)	L_1	L_2
0	0	0
0.20	− 1000	11,190
0.40	− 3060	16,160
0.60	− 6300	19,530
0.80	− 7490	20,098
1.00	− 8220	20,200

3. 200 grams of a saturated liquid mixture (80 mol per cent nitrogen, 20 mol per cent oxygen) are mixed with 100 grams of saturated oxygen vapor.

What is the analysis of the product?
What is its quality?
What heat must be added to vaporize completely the mixture?

4. On the attached chart sketch the solution of the following problem:
The feed to a rectifying column is 20 per cent vapor and analyzes 55 per cent oxygen.

A reflux ratio of 2 is used in the column.
The product bottom is 95 mol per cent oxygen.
The distillate is 95 mol per cent nitrogen.

How many plates are there in the rectifying section, assuming 70 per cent plate efficiency? How many in the stripping section?
How much heat must be abstracted in the overhead condenser per mol of *feed*?

THE T-SQUARE PAGE

Officers
R. P. HEELSCHER
W. H. SEEGRIST
C. V. MANN
G. M. PHELPS
F. H. HEACOCK
A. L. TOBIAS

DEVOTED TO THE INTERESTS OF ENGINEERING DRAWING

WILLIAM E. STREET, *Editor*,
Agricultural and Mechanical College of Texas

Officers
N. D. THOMAS
H. C. SPENCER
R. R. WORSENCRAFT
F. M. PORTER
F. A. SMUTZ
W. E. STREET

OPPORTUNITY FOR SERVICE IN E. S. M. D. T. DRAFTING FOR ENGINEERING DRAWING DEPARTMENTS

The rapidly expanding defense program is in need of every trained workman that industry and the educational institutions of America can supply. Draftsmen are in demand in the government service, shipyards, fabrication plants, airplane factories, etc. Workmen are in demand that can read blue prints and industrial plants employing thousands of new men every month find it impossible to secure men that can read blue prints.

Engineering Drawing Departments are in a position to render excellent service in the training of draftsmen and in giving courses in blue print reading to up-grade employees in their present positions. Short courses where the student spends all his time in school or evening courses giving instruction from six to nine hours per week are accomplishing good results. The kind of course needed will depend on the industry being served and the previous training of the workmen.

* * * *

Students and teachers in the Southwest are interested in the National Drawing Contest sponsored by the Drawing Division and they are desirous that the contest be held yearly in the future. Some schools are holding local drawing contests this year.

ITEMS OF INTEREST

The list of engineering curricula accredited by E. C. P. D. up to October 30, 1941—a total of 565 curricula at 129 colleges and universities—is included in the annual report, which contains the proceedings of the 1941 annual meeting. These include: the report of the chairman, President R. E. Doherty of Carnegie Institute of Technology; reports of the standing committees on Engineering Schools, Student Selection and Guidance, Professional Training, and Professional Recognition; a preliminary report from the committee on Engineering Ethics; report of the committee on Information; financial statement for the year ending September 30, 1941; reports from representatives of the national engineering organizations sponsoring E. C. P. D. Also contained in the annual report are summaries of the addresses presented at the annual dinner; list of E. C. P. D. officers, representatives, and committee personnel for 1941–42; the charter and rules of procedure of E. C. P. D.; and a list of available publications. Copies of the annual report may be obtained at 25 cents each from E. C. P. D. headquarters.

PURDUE UNIVERSITY

Nineteen additions to the teaching, research and administrative staffs of the Schools of Engineering were made for the year 1941–1942:.

W. M. Hesselberth, M.S., University of Illinois; J. R. Clark, M.S., Purdue; D. J. LaMothe, Michigan School of Mines; and R. C. Webb, University of Denver, were added to the Electrical Engineering teaching and research staffs. W. Vendley, Instructor, M.A., Northwestern University, to General Engineering. E. J. Ritter, M.S., University of Toledo, and R. B. North, B.S., Ch.E., Purdue, to Chemical Engineering. R. L. Sloane, Instructor, M.C.E., Ohio State, and R. C. Kany, A. H. Layman, D. W. Lewis, and M. J. Yohalem, Purdue University, to Civil Engineering School and Highway Research. R. W. Leutwiler, Instructor, M.S., University of Iowa; W. L. Sibbitt, Instructor, M.S., M.E., Purdue, and A. D. Johnson, W. R. Woodward, and S. B. Anderson, Purdue, to Mechanical Engineering.

W. E. Vogler, Lafayette College, was made Director of Personnel. He was formerly industrial relations representative for the Socony-Vacuum Company. Wayne Musser, Purdue, is assisting in the work of the Personnel Office.

UPPER NEW YORK STATE SECTION

The first meeting of the newly-formed Upper New York State Section was held December 6, 1941, at Syracuse University and 91 were in attendance; the papers resulted in very interesting discussions; and plans were laid to hold the second annual meeting during the fall of 1942 at Cornell University.

The retiring officers are: E. F. Berry, Syracuse University, Chairman, in charge of the Syracuse Meeting; H. A. Weiss, Clarkson College, Vice-Chairman; G. E. Grantham, Cornell University, Secretary-Treasurer.

New officers: Paul H. Black, Cornell University, Chairman; G. E. Grantham, Cornell University, Vice-Chairman; Herbert A. Weiss, Clarkson College, Secretary-Treasurer.

NECROLOGY

Parke Rexford Kolbe, President of Drexel Institute of Technology for the past ten years, died February 28. Dr. Kolbe, who was in his sixtieth year, had been unwell for some time, but had been absent from his office for only ten days. Death was due to heart disease.

Dr. Kolbe became President of Drexel Institute in 1932, succeeding the late Dr. Kenneth G. Matheson. A native of Ohio, he received his first two degrees from Buchtel College, at which his father was Professor of Modern Languages, subsequently studying at Göttingen, Paris, and Heidelberg. Especially trained in linguistics, but always interested in the broader phases of education, Dr. Kolbe was, between 1905 and 1913, Professor of Modern Languages at Buchtel. In the latter year he was chosen first president of the newly incorporated University of Akron, of which Buchtel had been the nucleus, accepting, in 1925, the presidency of the Brooklyn Polytechnic Institute, a position he held until called to Drexel in 1932.

Dr. Kolbe was a member of the Society for the Promotion of Engineering Education, a trustee of the Evans Dental Institute of the University of Pennsylvania, a member of the Organization Committee and past president of the Association of Urban Universities. He was a member of the University Club, Akron and Washington, D. C.; Rotary Club; The Ohio Society of New York; the Twentieth Century Club of New York; and the Rembrandt Club of Brooklyn.

John T. Walther, head of the Electrical Engineering Department of The University of Akron, died unexpectedly at his home November 4, 1941, while preparing to go to his classes at the University. He has served on the University faculty since 1920, and was one of the most popular professors in the engineering department.

He was graduated from the University of Michigan in 1909, with the degree of bachelor of science in electrical engineering. After graduation, he worked at the Westinghouse Electric Co. in Pittsburgh, coming to Akron in 1917.

Professor Walther was electrical engineer at the Firestone Tire & Rubber Co. from 1917 to 1919, when he took over the task of laying out the new Firestone electrical substation. He directed the planning and specifications of power lines, switchboard and other details of the station. He became an instructor at the University in 1920, and through the years advanced to the position he held when he died. He was a member of the American Institute of Electrical Engineers, and was faculty adviser for the University Chapter of the A. I. E. E.

THE TEACHER'S DUTY

By ALFRED H. WHITE, President

Some of the teachers of our engineering colleges have been given leave of absence and are now wearing the uniform of the armed forces. Others are giving their whole time as civilians to the government or to corporations manufacturing equipment essential to our war effort. Many of those who are still teaching are wondering whether they also ought not to discontinue their peace-time duties and devote their abilities and professional training to work which may perhaps be of more direct importance to our country. Part of the unrest among our younger teachers is due to the lurking fear that their draft boards may not recognize the importance of their present duties and may require them to enter the army in a capacity where their professional training will have little value. Some of the draft boards have been uninformed. Others have been hard put to it to fill their quotas and have sometimes been forced to appear unsympathetic to requests for deferment.

There is no doubt about the general principle that every man, and woman too, should devote his energy to the task for which he is best qualified and in the place where he is most needed. If this ideal could be realized there would be much greater progress in our national effort and more peace of mind for each of us.

The operators of welding torches and of the complicated machines of industry may be trained to do their one job in a few weeks, and intensive schools for these purposes are being successfully operated in many industrial centers. These short courses cannot, however, furnish the personnel required for the larger fields of design and supervision which require men with broad general knowledge and thorough professional training. All studies indicate that the shortage in professionally trained personnel is as great as that in airplanes or ships. A recent estimate of a competent official of the War Production Board showed a shortage of 80,000 trained engineers, with recruits coming from the colleges at the rate of less than 15,000 a year.

The new War Man Power Commission has been given wide power to determine and allocate both the military and civilian requirements of the whole nation. When this Commission announces the results of its studies and sets quotas for the various divisions of the war effort, there will be an end to much of the unrest which now distracts too large a proportion of our adults in all walks of life.

It is a certainty that our engineering colleges will be told that their work is essential to the war effort, and that they must maintain their staffs at high efficiency. Our teachers should understand the situation and recognize their obligation to remain at their posts, unless the college authorities agree that they can be spared for a particular piece of work for which they have unusual qualifications and whose urgency is great. Teachers in engineering colleges may have complete confidence that they are now engaged in work essential to the war effort.

ACCELERATION OF ENGINEERING PROGRAMS

SUMMARY OF REPLIES TO THE QUESTIONNAIRE ON PLANS OF THE ENGINEERING COLLEGES FOR THE COMING YEAR

The responses from administrative officers of engineering colleges to the questionnaire on plans of operation during the war were prompt, complete and definite. The Committee on the Acceleration of the Regular Engineering Programs is very grateful for the information so cheerfully furnished and is happy to summarize the replies for the benefit of those who supplied the statistics.

Of the 126 colleges from which reports were received by April 9, 1942, 103 plan to accelerate their regular programs and graduate students in less than the usual periods. For non-coöperative plan colleges this period is in general two years and eight months or three years, and a corresponding reduction in time is proposed by the coöperative institutions. On a percentage basis, 81.7 per cent of the colleges from which replies were received plan to accelerate. More than a year ago engineering college administrators were asked by this Committee whether they would be willing to accelerate their programs and the percentage of affirmative replies was 59.5 per cent. Performance has exceeded promise, doubtless because of Pearl Harbor.

In all but one or two instances, graduation dates are to be advanced without any sacrifice of courses or abbreviation of teaching. The gains are secured entirely by operating the colleges for more weeks in the calendar year than are normally used. In most institutions there will be 48 weeks of college classes in each 12-month period.

Thirty-six colleges will change from their present schedules to three equal-length terms, 16 will adopt four equal-length terms, 34 will simply add summer sessions to their usual academic year, and 7 will adopt various plans other than those mentioned.

Many colleges failed to state whether or not normal and accelerated programs would be conducted simultaneously. However, of the 82 replies to this question, 50 or 61 per cent were affirmative.

Accelerated programs will be provided for the classes in the various colleges as follows:

For the present juniors only	10 colleges
For the present juniors and sophomores	4 "
For the present juniors, sophomores and freshmen	4 "
For present students and the next entering class	69 "
For other combinations (mainly coöperative programs)	16 "
	103 colleges

In 67 per cent of the colleges, therefore, *all* undergraduate students will be following an accelerated schedule.

In 22 colleges graduation exercises for the present senior classes will be held as previously announced. In others the dates will be advanced as given in the following table:

Weeks before announced date	1	2	3	4	5	6	All others
Number of colleges	19	15	15	18	9	5	6

Dates for the opening of the summer term in 1942 have been announced by 97 colleges. They are distributed as follows:

May	17 colleges
First half of June	53 "
Second half of June	23 "
July	4 "

Seventy-one institutions reported definite summer vacation periods as follows:

Length of vacation in weeks	1	2	3	4	5	6
Number of colleges	16	21	15	13	5	1

Of 100 colleges reporting admission dates, 77 will enroll new freshmen classes in the early summer of 1942. The table below groups the engineering colleges according to the number of entering classes that will be registered each calendar year:

New class admitted per year	1	2	3	4
Colleges	20	34	33	13

Student fees for the accelerated programs were reported by 85 colleges. At 69 of the 85 colleges (81 per cent) the fees for the additional terms will be the same as for the present terms of corresponding length. At 3 colleges there will be increases, while 13 colleges will charge less proportionately for the extended instruction.

In general, the replies from administrative officers indicate careful study of the problems of acceleration and an earnest desire that the colleges do their utmost to meet the serious shortage of engineers.

For the Committee,

D. B. PRENTICE, *Chairman*

April 9, 1942.

EMPLOYMENT STATISTICS OF THE ENGINEERING CLASS OF 1942

Dean A. M. Greene, Consultant for the War Production Board, supplies the following figures concerning the engineering graduates for 1942:

Total probable graduates			14,987 = 100%
Enlisted in Army	3341	22.3%	
Enlisted in Navy	1783	12.	
Total armed forces	5124	34.3	
In teaching or graduate study	101	1.5	
In Industry	8275	55.2	
In Civil Service	533	3.5	
Not decided	954	6.3	14,987 = 100.8%

143 institutions answered the questionnaire out of 147. University of Alaska, University of Hawaii, for obvious reasons did not reply. Only two other institutions failed to answer, in one institution, the questionnaire did not reach the proper person in time for the answer to be included in the above.

ENGINEERS ARE NEEDED

On April 27, 1942, your Secretary sent the following telegram to every dean of engineering in the United States:

There will be mailed to you this week from United States Office of Education information pamphlet on "Engineers Are Needed." This program is sponsored by War Production Board, U. S. Office of Education and Society Promotion Engineering Education. You are urgently requested to exert all your influence in seeing that this coöperative effort between secondary schools and engineering colleges is made effective so that our colleges will be assured of properly prepared students in adequate numbers to serve more effectively the war production program.

On April 29, 1942, this pamphlet, "Engineers Are Needed," together with the following letter was sent to each president and dean of engineering school by J. W. Studebaker, U. S. Commissioner of Education:

On April 27, there was sent to each engineering school a copy of a document entitled "Engineers Are Needed," issued by the U. S. Office of Education. A copy has also been sent to every secondary school in the United States.

This material was the product of the joint efforts of the Occupational Information and Guidance Service of the Office of Education and the Executive Committee of the Society for the Promotion of Engineering Education. The executive committee in particular reviewed the suggestions concerning engineering schools. The committee had the benefit of the advice of Dean Emeritus Arthur M. Greene, Jr., of Princeton, now Special Consultant to Chairman Donald M. Nelson of the War Production Board.

The plan described in "Engineers Are Needed" calls for certain action by the engineering schools. This action, of course, is purely voluntary. On the other hand, it is believed that the adoption by engineering schools of the suggestions included in the plan will not only aid the war effort by increasing the supply of engineers, but will also result in specific benefits to the several institutions.

In view of the above facts certain suggestions are offered as to ways in which the engineering schools may implement their coöperation.

I. *Internal action by engineering institutions.*

Internal action by engineering institutions is described on pages 1, 2, and 3 of "Engineers Are Needed." Steps in this action are:

1. A follow-up study of drop-outs, 1936–1941.

   The form of questionnaire used as a follow-up for students who dropped out between 1936 and 1941 may vary from institution to institution. A suggested questionnaire form is included as appendix A for the use of any institution which may desire to employ it. It may be modified in any way, or used as it is without further permission.

2. A classification of students enrolled during the current year and steps to be taken after this classification has been made.

   It is thought that the usual facilities of deans and registrars' offices will provide adequate statistics and other means of making this classification. Therefore, no specific suggestions are advanced. It is urged, however, that this method of salvaging the 1941–1942 enrollment be attacked at once.

3. The determination of quotas expected from preparatory schools and consequent correspondence with these schools.

   The determining of tentative quotas and the consequent relation with preparatory schools should be considered in the light of suggestions on page 4, as well as the remainder of the document from pages 5 to 16 directed specifically to secondary schools.

II. *Reciprocal action between engineering institutions and secondary schools.*

1. In order to gain a comprehensive view of the secondary school relationship, the engineering school will need to study rather carefully pages 4 to 16 of "Engineers Are Needed." The following items will serve as a convenient checklist for steps which need to be taken by the engineering institutions.

   a. Become acquainted with the guidance and selection procedure which the secondary school is asked to follow.

   b. Become acquainted with the norms or other scales of the standardized tests suggested.

   c. Communicate with the respective schools to: Suggest quotas; make the most practicable arrangements for contact with school officials, whether personally or by mail; send material descriptive of the engineering institution useful to the school and its pupils for guidance.

   d. Study what correlation, if any, may be desirable in the opinion of the individual institution between its present admission plans and the procedures suggested.

III. *Using "Engineers Are Needed" to supplement admission lists already partially made up.*

It is recognized that, since the time is somewhat late, many institutions already have preliminary lists for their next freshman classes. Such an institution may desire to modify the present status of its next freshman class in view of assistance which may now exist because

each of its preparatory schools has been provided with a copy of "Engineers Are Needed."

1. Communicate with schools suggesting that they supplement such admission procedures as the engineering institution has already required by other steps described in "Engineers Are Needed."
2. Use the wartime manpower situation as a basis for requesting a new list of applicants made up in accordance with the suggested procedures. "Form A" of the Plan should be of special assistance.

IV. *Summary.*

It is reëmphasized that each institution is, of course, free to take any action it desires. It is also suggested, however, that the present emergency and the specific means provided by "Engineers Are Needed" may be used as a means of securing from secondary schools a more objective, impersonal, and unbiased recommendation of their students for entrance to engineering institutions than has been the custom in some schools. Such a result is essential to any further steps taken by engineering schools to graduate a much larger proportion of their freshman classes. Acceleration programs accentuate the problem.

HOST INSTITUTIONS FOR THE FIFTIETH ANNUAL MEETING

Below are the final thumbnail sketches of host institutions now making plans to welcome you at the Society's Fiftieth Annual Meeting in New York City on the weekend of June 27th. In the two preceding issues we made you acquainted with the other host institutions, and with this issue the picture is now complete. The June issue of the JOURNAL will carry all available information on arrangements for the Annual Meeting; meanwhile, we introduce you to the last four institutions on your list of hosts.

PRINCETON UNIVERSITY, SCHOOL OF ENGINEERING

BY KENNETH H. CONDIT

Engineering at Princeton reaches back two-thirds of a century. The 1874 issue of the catalogue of the College of New Jersey, as Princeton was then called, contained the first mention of engineering in its announcement that students in Civil Engineering would be accepted in September of the following year.

Under the leadership of Professor Charles MacMillan, the first professor of engineering, the work in civil engineering soon developed into the Department of Civil Engineering. The roots of a similar department in electrical engineering were already strong in the Department of Physics, which Professor Joseph Henry had started in 1832.

In 1873 Cyrus Fogg Brackett came to Princeton to occupy a new professorship of physics, founded in honor of Professor Henry, who had meantime gone to Washington to organize the Smithsonian Institution. Professor Brackett's work led, in 1889, to the formation of a Department of Electrical Engineering, one of the first formal courses in that field organized in the United States.

In the fall of 1921, after nine years of preparatory study and discussion, the trustees and the faculty of the University adopted the Princeton Engineering Association's plan for a full-fledged School of Engineering covering the principal branches of the profession and providing for both undergraduate and graduate study. At that time Arthur M. Greene, Jr., became Dean of the School of Engineering and began the long and arduous undertaking of converting a set of principles into reality. Today nearly one-fifth of the student body of the University is enrolled in the School of

Engineering; the engineering faculty numbers twenty-four professors and instructors, and since 1928 the School has had a modern engineering building to house most of its laboratories and all of its offices and classrooms, lecture halls and library.

Princeton is on a spur line of the Pennsylvania Railroad just fifty miles from New York City. Better trains take about an hour from New York. It may be reached by automobile via routes U. S. 1 and N. J. 29; the former passing within two miles of the campus

John C. Green Engineering Building, Princeton University.

and the latter connecting at Somerville with route 31, which leads directly into Princeton. Running time over either route is approximately one and one-half hours.

Many historic buildings are to be seen at Princeton and there are several good inns and restaurants. The campus in June is one of the most beautiful spots in New Jersey and well worth a visit.

RUTGERS UNIVERSITY

By HAROLD E. ORFORD

Rutgers is one of the nine Colonial Colleges in the United States sharing with Harvard, William and Mary, Yale, Pennsylvania, Princeton, Columbia, Dartmouth, and Brown, a distinctive origin dating from the time of the Declaration of Independence.

Rutgers, one of the youngest of these colleges, was founded as Queens College, November 10, 1766, by charter granted in the name of George III of England. It was not until 1825 that the name was changed from Queens College to Rutgers in honor of Colonel Henry Rutgers, a prominent citizen of New York City. In 1864

the State of New Jersey declared Rutgers to be "The State College for the benefit of agriculture and the Mechanic Arts." In 1917 Rutgers was designated by the legislature as the State University of New Jersey.

The University is located at New Brunswick, New Jersey, a town of about 40,000 inhabitants, on the main line of the Pennsylvania Railroad, thirty miles from New York and sixty miles from Philadelphia.

"Old Queens" Administration Building, Rutgers University; built 1825.

The campus, including the College Farm and the New Jersey College for Women, comprises over 1500 acres. The College for Men is near the center of New Brunswick, about five minutes walk from the Pennsylvania Station, while the College for Women and the College Farm are located about two miles away on the outskirts of the town. A recent addition to the grounds is the stadium and athletic fields which are located across the Raritan River from the main campus. Here, about 300 acres are devoted to a nine hole golf course and several athletic fields.

During the current academic year there are 1630 undergraduate students enrolled in the Colleges for Men, and 998 in the College for Women. The enrollment in the College of Engineering is 266.

Courses in Engineering have been given at Rutgers ever since it became the Land Grant College of New Jersey in 1864. The first Professor of Electrical Engineering was appointed in 1903, and the Department of Mechanical Engineering was organized in 1908. The College of Engineering became a coördinate unit of the University in 1914 when the first Dean of Engineering was appointed. Curricula are now offered in Civil, Sanitary, Electrical, and Mechanical Engineering. With the exception of the Sanitary Engineering curriculum all curricula are essentially identical for the first three years.

A new three story wing has just been added to the Engineering Building to provide additional space for an enrollment which has increased over fifty per cent in the last five years. A new machine shop, fuels laboratory, communications laboratory, several class rooms, and an auditorium seating 600 persons are provided by the new addition.

Some of the newest laboratory equipment in the Engineering Department may be of special interest to engineers. The Fuels Laboratory has a special C. F. R. (Coöperative Fuels Research) engine, equipped with a dynamometer and high speed crank shaft. The Mechanical Laboratory has a compact eighteen inch wind tunnel, which has many of the advantages of much larger installations. The foundry and metallurgy equipment is of special interest because of its flexibility. The various melting and heat treating furnaces, both gas and electric, are able to give students a demonstration of various types of foundry practice. At the same time the equipment is partially portable and the foundry space may be utilized for other purposes if the occasion arises. A new Baldwin-Southwark 200,000 lb. hydraulic testing machine has just been installed in the Materials Testing Laboratory. This machine of the latest design utilizes the Null weighing process, and has been calibrated to an accuracy of three tenths of one per cent.

Rutgers University has adopted an accelerated program because of the National Emergency. The Engineering Department will be operating on a modified schedule this summer, with full courses for the seniors. A cordial invitation is extended to all who would like to visit the classes and laboratories, many of which will be in operation during the summer months.

STEVENS INSTITUTE OF TECHNOLOGY.

By JAMES CREESE

Stevens Institute of Technology occupies a promontory known as Castle Point, at Hoboken, New Jersey on the west bank of the Hudson River, opposite Twelfth Street, New York. This isolated

hill, separate from and almost a mile in front of the southerly continuation of the Palisades, commands a view of the full length of Manhattan Island.

In its name and by reason of its location at Castle Point, Stevens Institute of Technology perpetuates an unusual tradition in engineering. Colonel John Stevens purchased from the State of New Jersey in 1784 the grounds now included in the College. Here he

View over the Campus of Stevens Institute of Technology toward New York.

planned the first condensing double-acting engine designed on the American continent. As early as 1825–26, he experimented with the first locomotive in America to run under steam on a track. (A full sized model of this locomotive is now exhibited in the College museum.) Colonel Stevens' sons continued the development of steam navigation and railroad transportation, and incorporated the Camden and Amboy Railroad in 1830. The second of these sons, Edwin A. Stevens, founded the College which was incorporated in 1870 and was opened for admission of students in 1871.

Today the College has an enrollment of 630 students in the four-year undergraduate course leading to the degree of Mechanical Engineer. An evening graduate school, established in 1938, has an enrollment of 503, graduates of 75 colleges and universities.

Of special interest to visitors at Castle Point are the Administration building (1870) in the auditorium of which the A. S. M. E. was founded in 1880; the Library, particularly the Lieb Memorial Rooms containing collections related to the works of Leonardo da Vinci and a library of reference on the work of Frederick W. Taylor, originator of scientific management; and the College museum exhibiting a remarkable collection of early automobiles. Laboratories and buildings for instruction occupy the southerly portion of the College grounds; athletic fields, dormitories, and faculty residences are located on Castle Point proper, with Castle Stevens (1853) at the top of the hill.

Among unique special laboratories are the Towing Tank Laboratory for the testing of ship and yacht hulls, a powder metallurgy laboratory installed in 1939, the Stevens Theatre currently engaged in investigations of the dramatic uses of sound and light, and a laboratory for research in aptitude testing.

Visitors from New York City should allow approximately thirty minutes for the trip to Stevens: by bus No. 63 from the New Jersey Public Service Station, 42d Street and 8th Avenue (via Lincoln Tunnel); and by Hudson and Manhattan Tubes from 32d Street or the downtown terminal at Fulton Street. Ferries to Hoboken leave terminals at 23d Street, Christopher Street, and Barclay Street, New York.

WEBB INSTITUTE OF NAVAL ARCHITECTURE

By LYMAN J. BALLARD

Webb Institute of Naval Architecture is probably the smallest of the Colleges of Greater New York which collectively are to be host to the members of the Society for the Promotion of Engineering Education at the coming annual meeting in June, 1942.

The Institute, at Webb and Sedgwick Avenues in the Borough of the Bronx, with its building rising high on Fordham Heights overlooking the Harlem and Hudson Rivers, is set upon a spot of historic interest. The site of the Institute, originally a 14-acre plot, now eight and one half acres, was formerly part of the old Manor of Fordham, purchased largely from the Indians by John Archer during a period of years from 1655 to 1671. Through changes in ownership, which included the names of Cornelius Steenwyck, the Nether Dutch Church, Lewis Morris, the British

during the days of the Revolution, and Samuel Barlow, the property came finally into the possession of Mr. Webb in 1888. All around were farms. There was no bridge from Fordham to Manhattan. Berrien's Landing, on the Harlem River about a mile south of Fordham Village, was a stopping place for the boats running up and down the stream. Here Mr. Webb decided to carry out a life's dream, and build an Institute which would furnish to any young man, a native or citizen of the United States, a free education in the art and science of shipbuilding, together with

Webb Institute of Naval Architecture.

board, lodging and the necessary materials while obtaining such an education, provided he proved himself upon examination, to be competent, of good character and worthy.

A native New Yorker, born in 1816, Mr. Webb had acquired his education the hard way, by serving his apprenticeship in his father's shipyard. From 1843 until his retirement in 1872 he operated his own shipyard, located in New York City on the East River waterfront, and from it were launched many notable clipper ships which took full share in the dramatic, racing rivalry in the sea trade of America in the middle of the 19th Century.

During Mr. Webb's shipbuilding career the apprenticeship system had to be relied upon to produce designers and builders, there being no school in this country prepared to teach the science of shipbuilding. His vision of the future requirements of our navy

and merchant marine and his wish to assist young men to obtain, with minimum sacrifice on their part, the education he had acquired with such difficulty, prompted him to set aside a portion of his wealth to found an institution to provide this education. And so the Institute which bears his name was founded in 1889, and formally presented to the Trustees in 1894 with an ample endowment to provide for its maintenance and support of the students.

The first class was graduated in June, 1897, and since that time approximately 400 Naval Architects and Marine Engineers have received their education at Webb Institute, and are today taking an important part in the building of our two ocean navy and our large and rapidly increasing merchant marine.

Webb Institute has been fortunate in having at its head for the past nine years, a man exceptionally well fitted for the position, Rear Admiral George H. Rock, at one time Chief of the Bureau of Construction and Repairs of the United States Navy. He is striving to give our students a broad view of their possible influence when they leave school and enter professional life, and urges them to reach beyond the limits of engineering in its narrower sense, and help solve the humanitarian, economic and political problems of the day. He and his faculty extend a hearty welcome to the members of the Society for the Promotion of Engineering Education, and shall do all we can to make your stay here in New York pleasant and profitable.

PROBLEMS OF JUNIOR COLLEGE STUDENTS WHO PLAN TO GO ON TO ENGINEERING SCHOOLS*

By FRANK B. LINDSAY

Assistant Chief, Division of Secondary Education,
California State Department of Education

This paper proposes briefly to explore some of the problems of junior college students who plan to go to engineering school with respect to their preparation in fields of knowledge fundamental to enabling them to render creditable services to the interests of the nation. Consideration of the preprofessional training of students for engineering within the secondary interval of their education—that is to say, beginning at grade nine or ten and through fourteen, inclusive of their high school or senior high school and junior college or lower division schooling—is all too liable to become a mere listing of conventional courses in mathematics, physical science, draughting, surveying, and strength of materials or jigs and fixtures. Indispensable as mastery of these foundation subjects is for the study of engineering, they by no means exhaust the number of fundamentals essential to successful practice of any one of the engineering professions. For the engineer does not pursue his vocation apart from the industries and businesses that require his services. He is a citizen with real responsibilities to the social structure his technology has produced. And he owes to his profession as well as to his personal professional future to make sure that he does not tend too early toward narrow specialization which may obscure insight into possible new fields for technological advances. Particularly at this time when we are under pressure to graduate engineers at the earliest stage of their growth, we need to assess the elements essential to insure his maximum contributions to wartime and postwar national security.

At the outset, a principle of rigorous selection of student candidates for engineering is to be insisted upon. There is great need for many to be trained in engineering. But these must be the competent and intelligent. There is no place at engineering school for the second rate—least of all during a national emergency. The elimination of those ill-suited for engineering training from its

* Presented at Meeting of the Pacific Southwest Section, Fresno State College, December 29, 1941.

pursuit is a responsibility the junior college should boldly assume. For if this institution transfers to engineering schools persons incapable of profiting by professional training, the engineering colleges can have no choice but to drop them. This means wasted expenditure of time and human energy both for the engineering school and even more for the students dropped. The limited funds and faculties of engineering schools especially need to be conserved at present for investment in employable engineers. And the other students will have been made to suffer needless humiliation through expulsion, the tribulation of trying ineffectually to master subject-matter beyond their mental powers, and the dangerous postponement of their securing vocational training of use to them. The junior college has a duty to these young men to divert them as soon as possible from their fruitless pursuit of unattainable professional training toward semiprofessions and skilled trades where their aptitudes and interests find useful scope. It is particularly important today that young men not waste their junior college years since their own economic security as postwar adults very likely will depend upon their acquiring some saleable skill before they reach the age when conscription intervenes to remove them from schooling.

The first problem then of a junior college student who plans to go to engineering school is frankly and fully to face his mental limitations as well as his desires. Recent researches of Thurstone and other psychologists tend to show that an individual may have high orders of intelligence in several directions yet lack the combination requisite for success in a given vocation, such as engineering.

A student's junior college counselors and classroom instructors, who need fully to be acquainted with the degrees of ability demanded for success in engineering, should help him form a profile of his aptitudes and their present apparent development. The secondary schools are precisely the places where youth should make its mistakes, face its failures in a given direction, and rechart its course. As the senior level of secondary education, the junior college should insist that its students employ themselves with industry, conscientiousness, studiousness and perseverance at studies they can do. For though in California any high school graduate or young adult has leave to enter a public junior college, that institution is under no legal obligation to discharge any purely custodial function in his behalf. For the junior college does not have to carry along young people whose presence is secured unwillingly through the force of statutes of compulsory education. The people of California, like those of other states, wisely require that during the most critical years of adolescent vagaries their children stay in high school. But a junior college education is a privilege to be earned through creditable and consistent performance.

This is not to say that students are to be peremptorily discouraged from attempting engineering at the momentary caprice of any harried, overwrought instructor. Nor can poor teaching be excused by postulating the deficient mental endowment or defective high school preparation of any current generation of junior college students. The preprofessional training of engineers should be rigorous, but also it must be competent and sympathetic. Personally, I distrust the teaching ability as well as the common sense of an instructor whose sole claim for maintenance of high standards in his courses rests upon the imposing percentage of students he fails! The increasing demand for engineers should stimulate junior college instructors to review their effectiveness as teachers. It is to be feared that sometimes teachers of elementary calculus and introductory physics and chemistry insist upon a slavish ritual of topical sequence that ignores the psychological set and previously developed interests of young men today. Engineers are people and are educable as such. Nor would they become better engineers could they be reduced to subject-matter automata. The engineering profession is no better than the rank and file of its professors; its progress toward new technological triumphs depends as much upon their resourcefulness and versatility as upon their habituation to conventional formulations of knowledge.

The viewpoint expressed at the beginning of this paper implies, however, that junior colleges must concern themselves in preprofessional engineering preparation with more than the simple mathematics and physical science ordinarily associated with the engineering curriculum. The junior college shares with the high school a duty to their prospective candidates for engineering training to see that modern requirements for participation in industry and business are begun to be met. Is it too much to insist that every high school graduate presently shall have acquired some facility at typing? Or to demand that junior college engineering students add machine calculation to their attainments? And training in mathematics and science has been defective unless it has emphasized the writing of concise businesslike reports and direct oral presentations. Like proper posture and good manners, command of an adequate vocabulary, correct enunciation, accurate spelling, with brevity and comprehension in oral and written expression—these are as much needful for the young engineer as for any other person in a business or public character. But I would have you consider a more ample concept of engineering training such as Vice-president Walter Mathesius of the United States Steel Corporation stated in the October, 1941, JOURNAL of our Society as an industrialist looking at engineering training:

It is obvious that engineers must be effective technologists, but it is also necessary that this profession, in order that it may render creditable services to the interests of the nation, be able to recognize and analyze correctly the many varied and complex economic, commercial, or human problems which beset the majority of industrial developments today. . . . It is my conviction that the essential objective of higher education in engineering should certainly not be the graduation of specialists, but rather the building of good citizens, equipped with fundamental knowledge, and trained in logic.*

In order that the already overcrowded upper division years of engineering school may not be further overloaded, the institutions of secondary education must provide in considerable part the non-technical equipment for participation in citizenship. The junior college must insist that pre-engineers make preparation for the engineer as businessman as well as technician. Vice-president H. T. Heald of The Society for the Promotion of Engineering Education has well set forth the role of "The Engineer in a Post-War World" in the December, 1941, JOURNAL:

. . . the technical man is not only the author of our progress but is to be the author of our survival. Technology has created a higher standard of living in the past, but its future task must be to preserve the American traditions of democracy, free enterprise, and the capitalist system. . . . And above all we must train men to a degree of efficiency in management heretofore unattained. . . . We must teach them to approach each new problem with an insight into its social and technological implications." †

The junior college cannot consider its task commendably done so long as its transfers to engineering school are social, economic, and political illiterates. There must be incorporated into the engineering curriculum more than mere pious verbal genuflections in the direction of democratic ideals. Grim necessity arising out of our mortal struggle against totalitarian powers demands that our youth go forth for battle to the death as well equipped ideologically as the generation of fanatic Nazis and Japanese youth who have resolved to extirpate the democracies. The most difficult way of life to operate is ours, attended as it is by representative government, popular ballot, free speech, free press, freedom of conscience, the spirit of free inquiry and scientific research, the right of the majority to conduct and of the minority to criticize the government, and the privilege of each to develop his capacities to the highest possible degree. It would be the poorest service to

* Mathesius, Walter: "Coördination of Industry with Engineering Colleges," THE JOURNAL OF ENGINEERING EDUCATION, October, 1941, pp. 307–312.

† Heald, H. T.: "The Engineer in a Post-War World," THE JOURNAL OF ENGINEERING EDUCATION, December, 1941, pp. 305–306.

our profession to let its oncoming membership graduate ignorant of the very political and economic conditions which allow them freest scope for the practice of engineering. Speaking before a group of physicists, Charles F. Kettering once said, "A physicist within a university has only two factors in his problem to deal with. They are material and energy relationships. But when you go outside into an industry you have four factors. You have the material and energy relationships the same way, but you have economics and psychology added to them. . . . It isn't the fact that the thing will work that is important; it is whether the fellow you do it for likes it and whether he is willing to pay for it after it is done." *

At this point I fear the patience and instinctive courtesy of my junior college listeners may be badly strained unless I interrupt this recital of "musts" and "oughts" to indicate how I expect the junior college to give instruction adequate for participation in democratic procedures without endangering the teaching of essential engineering. Here is our opportunity to experiment and to pioneer in another promising educational development. For the imparting of thorough understanding of the purposes, ideals, and operation of democracy, the building of a fundamental loyalty to its principles, and the gaining of practice in its processes are not truly measurable in terms of any schedule of classroom study and recitation but through daily living. The junior college must realize that instruction for its students occurs throughout their waking hours, and not merely during on-campus periods.

The junior college has long prided itself upon being a local and community institution. It has advertised that its students enjoy the advantage of access to its educational services while they remain at home and maintain customary normal community activities. In short, the junior college takes its own community for its social and political laboratory. Let it proceed to put its professions into practice. Let it assume leadership in coördinating programs of local civic, professional, business, and service groups so that preëngineering and other students outside of laboratory and draughtingroom will necessarily gain wholesome experiences in democratic living.

Junior college instructors in engineering subjects should urge upon their administrators to call together representatives of community enterprises to formulate and execute a total youth program for practice in democracy. (And don't forget to have youth represented in the planning!) Such requests might so surprise the administrators that they would develop a workable formula while

* Boyd, T. A.: "You and Research," THE JOURNAL OF ENGINEERING EDUCATION, April, 1941, p. 576.

under the spell of support and approbation of their most realistic faculty critics. Besides we owe to our students that engineers be as literate as social science majors with regard to utilization of community resources. We should explore the possibilities in our neighborhoods for tasks young people can perform for community betterment. These projects may be in the form of surveys, work with officials for community beautification, service in social agencies, coöperation with forces of law and order, and the devising of programs for building public morale.

To enforce the seriousness with which I urge the training of engineers for business and citizenship as well as in technology, in conclusion let me quote President Charles E. Wilson of the General Electric Company who wrote in *Survey Graphic* last April:

> How, in the midst of this dynamic world disorder, shall the capitalistic system—or what we, in this country, call the American free enterprise system—be sustained in its most useful form to provide economic security for all of the people in times of peace and plenty, in depression, in national emergency, and even in time of war?
>
> How may an ever broadening bulwark of public faith be built to protect this free enterprise system against communistic and totalitarian enemies, as it seeks to serve this purpose?
>
> . . . The simple answer seems to be that again and again and again the financial and managerial components of our free enterprise system must prove, by deeds as well as by words, their full comprehension of their social responsibilities, their sense of public service, and their capacity to plan, to put into effect, and, if you will, to police by self-imposed rules, a constitution for industrial and commercial progress acceptable to the majority of the people.
>
> Never before has the American free enterprise system been confronted by such a challenge. And never before has there been such an opportunity —or such an obligation—to prove the full worth of this system as an efficient, economical and trustworthy servant of society.*

* Wilson, Charles E.: "Total Security: a Challenge," *Survey Graphic*, April, 1941, pp. 244–246 and 263–264.

A REVISION OF THE UNDERGRADUATE CURRICULUM IN CIVIL ENGINEERING

By J. K. FINCH

Renwick Professor of Civil Engineering, Columbia University

The following brief paper is an outline of the educational philosophy which has led to a rather radical change in the program of undergraduate study in civil engineering in one of our American engineering schools. It should, however, have a wider interest, for the changes here noted have been brought about by influences which are not confined to any one school. They are influences which must sooner or later be taken into account by all progressive engineering schools. Few schools may find it possible, or believe it desirable, to make the changes here noted. But all schools should be interested in the solution here outlined.

The Department of Civil Engineering at Columbia has long had under consideration a rather radical change in its program of studies for the Bachelor of Science degree to meet some of the more recent trends in civil engineering practice, especially in the structural field. The truly progressive engineering school must not only keep abreast of current practice but endeavor constantly to appraise trends and future needs so that its students may be prepared and competent in the new techniques which will be developing three or four years hence when they graduate and enter practice. The engineering profession relies on our engineering schools, and to an extraordinary degree, to train the young engineer in the newer methods of analysis and design, the new techniques which are being continually evolved through modern study and research. In short the fertilization of engineering practice through the absorption, into practice, from scientific and technological research, of better and more fully rationalized procedures and methods, rests to a major degree on the adequate preparation and instruction of the young engineering graduate.

The engineering profession never has been, and let us hope never will be, static. Its technology is constantly being improved, perfected in application and broadened in scope. It is a dynamic profession and its technique is thus constantly changing. Educational requirements must, accordingly, be subject to constant review and continued revision and improvement. The old is in a continued

state of displacement by the new. This is the educational philosophy which is back of the changes here stated.

The major changes which Columbia has now adopted have been prompted primarily by the fact that in the normal evolution of structural design new methods and theories have been developed which are regarded as essential in the training of the engineer of tomorrow. The last twenty years have seen a remarkable—almost revolutionary—change in structural practice, not only in the greater exactness and fuller rationalization of design and analysis but also in the widespread use of continuous structures, the continuous truss bridge, the rigid frame, and in the evolution of reinforced concrete design to an almost completely "continuous" practice. Such structures are beyond the scope of the older, "classical," methods of analysis and design. Simple structures have been replaced by continuous structures and simple statics by the methods of statically indeterminate analysis. The greater economy of continuous design, an economy of material achieved without a sacrifice of stability, has been the main factor back of this advance. There has undoubtedly been another factor influencing this trend, stimulating this evolution—the rapid growth in the use of the aeroplane.

Aeronautical theory has been developing at a tremendous pace, and, through the development of aerodynamic theory, for example, has had a very stimulating effect on the progress of fluid dynamics and on our knowledge of basic hydraulic phenomena. But the remarkable evolution in the design of the aeroplane as a structure has also caused us to seek a fuller understanding of the mechanics of structural stability and to reconsider our standards of structural design. The continued search in aeroplane design for the minimum of weight consistent with stability—the premium put on saving the last possible pound of structural weight—has given a remarkable stimulus to the search for structural knowledge. It has, of course, led to the adoption of standards, of margins of safety and stability, which are far less than those which can be adopted for static structures such as bridges. But it is notable that the bridge designer began to give greater thought to elastic stability and problems of mechanics beyond the scope of the "common theories" of the older text books on "the strength of materials," with the advent of the modern aeroplane. Modern education cannot ignore the need of the modern engineer for an understanding of the limitations of the common theories and an introduction to the fundamentals of elastic theory. We have, therefore, introduced at Columbia in our B.S. program a course in the advanced strength of materials—essentially an introduction to elastic theory—and additional instruction in the analysis of statically indeterminate structures.

Since there is no room in our existing B.S. programs for new subjects, something old must be removed to make way for this development. The natural move is to replace by the new those older subjects which, however valuable in rounding out a course of study, can be acquired by the graduate through later study, apprenticeship and experience. Admittedly competence in such new subjects as statically indeterminate analysis and advanced strength of materials cannot be so achieved. The student needs guidance and assistance in order to secure a start in these new theories and techniques.

Accordingly at Columbia we have abandoned water supply, sewer design and sewage disposal as undergraduate subjects. Furthermore we have concentrated the old training in the computation of railroad curves and earthwork, route surveying, and the course, largely descriptive, in highway engineering, into a single three point course—the elements of transportation engineering. We feel that we have abandoned old friends, but the problem is one of concentrating on fundamentals—the fundamentals which cannot be "made up" by the unaided graduate.

It may, of course, be argued that the student who wants this new theory can get it through graduate study. But how many B.S. students go on to graduate study, particularly today? It may also be argued that we are asking too much of the undergraduate, that he is too immature, is incapable of mastering this more intricate and involved teaching. Our experience at Columbia does not bear this out—but I admit that our situation in this regard may not adequately reflect the usual or general situation of engineering schools throughout the country. The new program is obviously geared to the capacity of the better, the more able, student. The slow moving man of no special capacity will clearly fall by the wayside. Fortunately we have been able to pick and to choose. Almost a quarter century ago we abandoned the older strength of materials for a more searching version which went beyond the empirical mechanics of that day. Ten years ago our old descriptive course on foundations was replaced by the more scientific and rational approach through soil physics and soil mechanics. These new, and thus radical, changes were taken by our students without stumbling and with marked success. The capable undergraduate can do far more than we give him credit for—too much of our teaching is geared to meet the needs of the "border line cases," the students who should be doing something else or whose mental ceilings limit their efforts to that of the private in the engineering army—to the vital and important task of doing well the ordered and appointed work of each day.

It should be noted that with the abandonment of sanitary engineering as an undergraduate discipline we have not abandoned the

elements of hydrology formerly included in these studies. We feel that every graduate in civil engineering should know something of this subject—it is a fundamental. Accordingly a new, brief course is included on the elements of meteorology and hydrology and the basic relationships of supply and demand in water supply studies for public supply, water power and irrigation.

The criticism has been frequently made in the past that the so-called graduate courses offered by many of our engineering schools are merely continuations of undergraduate subjects and are graduate only because they are offered to graduate students. There will always be an element of truth in this statement. Undergraduate training progresses by the taking over into undergraduate teaching of ideas and methods first developed in the work of the laboratory and advanced classes. The graduate work of today will become, in part at least, recognized as undergraduate training tomorrow. There will thus always be some graduate courses which have undergraduate potentialities. On the other hand, graduate work which in scope and quality is distinctly undergraduate in character is not only misnamed but also lowers the standards of both graduate and undergraduate education.

One other point demands attention. Our European confreres have long been noted for the thoroughness and excellence of their theoretical training—and, too often, for the lack of any emphasis on its practical and economic application. We are undoubtedly moving toward similar, higher standards of theory and rationalization in our American engineering schools. As we so move we must make a determined effort to keep our feet on the ground. Progress in engineering is not measured by the volume of research or theory but in terms of current methods and standards of practice. We must seek, therefore, in advancing the standards of engineering education to keep the requirements of application constantly in mind—the inexorable laws of economy and of safe building, and the requirements of production and construction. This also implies that current theory must be translated into current practice and the engineering school can best aid in this movement by translating current theory into undergraduate teaching.

TEACHING AS ENGINEERING*

By FRANK W. THOMAS

President, Fresno State College

The term "Engineering" has been so loosely used during recent years that I have some hesitation when I seem to extend its techniques and procedures into still another field. Let me hasten to say that the point of view which I am about to present is based upon a profound respect for the rigorous, scientific principles which are characteristic of engineering, and I hope that my remarks will reflect throughout that point of view. As a matter of fact, it has been due to the efficiency of engineers that their responsibilities have extended beyond the strictly physical and material bounds which originally prescribed the field, into those human phases of organization which have reached their points of widest exploration under such designations as social engineering.

It will be pertinent to my purpose to mention some of the prominent stages through which the profession of engineering has gone in this expansion process. A typical example of the necessity of a more comprehensive conception was in the building of the Panama Canal. A great engineer who undertook that task realized that it was not merely the matter of machinery and cubic yards of materials, but it was primarily a question of sanitation, morale, and the safeguarding of human efficiency which were inseparable parts of the job. So many instances of engineering problems were dependent for successful solution upon an understanding of the human factors involved that there was a definite recognition of the greater conception in the revision of the curriculum for engineers nearly two decades ago at such institutions as the Massachusetts Institute of Technology and at California Institute of Technology. At the latter institution, for example, the engineer is expected to learn something of economics, political science, and the humanities, as well as mathematics and the physical sciences because his job will require such understandings.

To allay any misgivings that you may have by this time as to the danger of my spreading engineering over a nondescript array of activities and misuse of that honored term, it is proper to indicate at this point the sense in which I am using the term "engineering."

* Presented at the meeting of the Pacific Southwest Section, Fresno State College, December 29, 1941.

I should define it as the scientific direction of the essential forces and factors involved in any substantial undertaking to the end that projected results may be achieved. In short, the engineer takes stock of the conditions under which a job is to be performed, the material and tools with which he is to work, the sources of available energy, and proceeds to organize whatever forces are necessary to successful completion. In the sense that successful teaching requires an understanding and direction of the factors which help or hinder the attainment of desired results, it constitutes a challenge to the principles and techniques of a competent engineer.

Any job in engineering must begin with some definite specifications as to the product or results sought. Industrial engineering, for example, must be continually re-appraising the changing conditions of service and performance which machinery must meet, and the industrial engineer is constantly alert for means of revising and adapting his practices so as to keep in step with changing demands. He must fight against the tendency or temptation to keep old machinery simply because he already knows how to run it. In my opinion, the demands of engineering education are analogous, and I am assuming that the members of my audience are willing to revise continually their educational machinery and teaching practices in the interest of better results, even when this involves discarding some cherished and long used classroom mechanisms. In this connection the engineer will recognize the need for a rather wide margin of tolerance and adaptability because of the lack of uniformity of quality and characteristics in the human material with which he has to deal.

If teaching is to qualify as a worthy phase of engineering practice then it must be based upon a careful and impersonal analysis of the factors which have bearing upon the job to be done. These factors are numerous and complex. It shall not be my purpose to attempt any complete listing or even a thoroughgoing analysis of those three which I have chosen to use as examples. I am anticipating that the discussion which follows will amplify very generously the list, and I shall not be at all disconcerted if there should be emphatic disagreement with my own interpretation of these essentials. My chief purpose is to call your attention to the fact that any teaching which is worthy of being classified as a phase of engineering education should subject itself to the same scientific evaluation that any other engineering job requires.

Foremost among the principles upon which good teaching depends is the basic one that all learning must be built on experience. Reduced to its simplest terms, good teaching is the job of guiding the extension and interpretation of experience. Whenever the

words of the instructor cease to find vital anchorage in the experiences of the student, the transmission is out of gear and nothing is being produced. The whole scheme of laboratory teaching and laboratory practices in education is based upon the necessity of first-hand experience if accurate learning is to ensue. Laboratory teaching is good or bad just in the proportion to which it contrives to have the individual student acquire fruitful experiences and derive from them the conclusions and understandings essential to accurate thinking in that field. It is unfortunately true that many so-called laboratory activities result only in inconsequential fuddling around without arriving at either fruitful experiences or an intelligent interpretation of those that are potentially valuable.

Fortunately, our students come to us with many years of experience already encountered and it is not necessary to provide all of these in the laboratory or classroom. Good teaching must capitalize upon what the student already knows; perhaps upon experiences that had little significance for him at the time but which take on a thrilling meaning when related to new ideas. One of the most essential devices for utilizing potentially valuable past experiences is the use of pertinent illustrations. These may take various forms from anecdotes to graphic representations. Their function is not to entertain but to recall things already known to the student which have some vital bearing upon the new idea and which are in fact essential to its comprehension. A generous fund of effective illustrations is not only an invaluable asset to a teacher, but is also pretty good evidence that throughout his teaching career he has been conscious of the need of finding and perfecting such adjuncts to his work.

It sometimes happens that upon a relatively simple group of experiences there may be built up a highly complex and complicated system of conclusions. This is particularly true of mathematical abstractions. In fact, there is perhaps no other field of learning in which the unbroken series of progressive interpretation and application of previous knowledge and experience has been so thoroughly and admirably perfected as in the field of mathematics. From the actual first-hand counting and direct observation of number and spatial relationships the child is led to make simple mathematical generalizations. He learns to know that 2 and 2 make 4 without having to ask 2 what's and 4 what's, although they were actual objects in the original experience which made the generalization possible. In a similar way, he advanced through his elementary and high school mathematics, having need from time to time to bolster by real and objective experience the foundations of his abstractions. I recall how much clarity and confidence the process

of extracting the square root gained for me as a high school lad when I saw a graphic representation of the areas represented by x square, by y square, and by the two products of x times y. The teaching of mathematics must proceed by sequences in which the interpreted experiences of the previous stage constitute the foundation upon which the next level of abstraction must be built, and the teacher of mathematics who does his work in true engineering fashion will be continually alert to make sure that there are no unanchored stones in the foundation and no attempts to build any level on thin air because of a lack of sound mastery of that which should have gone before.

In this connection it seems appropriate to mention the dreary waste and futility that sometimes accompanies so-called lecturing in the classroom. Instead of looking, as an engineer would, for all factors involved, the ineffective lecturer is more like a truckman dumping his load without regard to whether anything is being done with the materials or whether, in fact, he may be cluttering up the place needed for a foundation. The skillful lecturer, whenever necessity compels a teacher to be a lecturer, will be constantly watchful for evidences that his listeners, or perhaps I should say, those who are sitting in front of him in a listening position, are utilizing their experiences in a busy kind of coöperative activity, constantly interpreting the lecturer's remarks in the light of the experiences which they have previously interpreted. He should be as watchful for the appearance of deadpans as the engineer is for evidence of a dead dynamo. The results in the way of loss or damage are similar. This need of a constant realization as to just what is happening all along the assembly line applies not only to lecturing but also to discussion or quiz meetings. One of the most heartening occurrences which may sometimes be observed in a discussion group skillfully conducted is the sudden way in which the faces of individual students will light up as they finally catch the significance of some perplexing generalization when it is related to experiences already encountered but not previously recalled or utilized for the interpretation of the new principle. I feel sure that almost every one in the audience could supplement these examples and I shall hope to hear some of them in the discussion. Enough has been said for the moment, I hope, to emphasize that teaching, if it is really engineering education, is constantly anchoring its advancing levels of construction on the firm basis of properly interpreted experience.

The second important factor in getting satisfactory results in teaching is that of student interest and its fluctuations. From an engineering point of view, the recognition of the degree of interest

at any time is our evidence, or gauge, of the available units of horsepower which are functioning. The amount of effective energy put forth by the student is directly proportionate to his interest or feeling as to the significance of the material under consideration. A competent engineer is always alert for leakage in the power supply and for causes of resistance or interference which are lowering the available energy. It is sadly true that many ineffective or incompetent teachers seem sometimes to be concerned only with feeding material into the machine, regardless of the extent to which it is being transformed into satisfactory products. There is a certain automatic reminder in the case of physical machinery, in that the apparatus chokes down if all stages of the process are not functioning. By contrast, there is an amazing variety of ways by which the human intellect evades and bypasses educational material directed toward it in situations in which the recipient feels no value or importance in the offerings. These defense mechanisms of the human mind afford all of us a priceless protection in these days of propaganda and quantities of trashy or useless reading matter that is pushed toward us. Although each of us present is confident that he possesses a discriminating judgment as to what is worth reading or listening to, it is equally true that our students have some ideas along that line also, and are not so wisely discriminating as to the values of assigned reading or exercises.

Perhaps the gist of what I am trying to say is that even an engineer must occasionally use salesmanship in securing the coöperating effort essential to the effective completion of an undertaking. By this same analogy, the teacher in the field of engineering education must sometimes provide highlights for values which the immature student would not otherwise recognize. Lack of interest is by no means indicative of lack of ability. It simply means that the potential horsepower is not being transmitted to the particular area where the work needs to be done. The average student has a latent reservoir of energy and of potential interests which are sometimes suspected only as they appear in lines of performance not approved by the teacher. It is a real challenge in engineering to find means of connecting this potential energy with the desired lines of effort. The ability of a superior teacher to capture this interest and turn it into profitable endeavor is second in importance only to the ability to utilize basic experiences in directing learning. Fortunately, skill in this line can be acquired and it is one of the most gratifying experiences of an educational administrator to observe growing facility in this respect on the part of an alert teacher who regards the discovery of newer and better ways to hold the interest of his students as a worthy field of research.

There is a third factor in the effective planning and direction of the students' activities which I wish to emphasize even though I recognize that there is danger of its carrying me to the outer borders of the field which I have chosen to discuss. I am referring to the need of diversification of teaching procedures in accordance with the quality and type of material among our students. Before attempting to develop this point as it applies to engineering education, I should like to comment upon a rough parallel in the work of a mining engineer. It requires no great competence to identify high grade ore and devise acceptable processes for its profitable utilization. The work of the real engineer is evident when comparably profitable results are obtained from the treatment of low-grade ore. Our output of copper, for example, reached its present volume largely because of clever engineering research on processes whereby low-grade deposits could be effectively salvaged. The good engineer does not dump ore on the refuse pile simply because it assays slightly below 70 per cent.

Even at the risk of seeming to digress, I should like parenthetically to set forth what seems to be a needed phase of reorganization in the total scheme of engineering education. In practically all of our schools of engineering the course of training has been planned and developed with a view to the production of only top ranking engineers. The result has been that an extremely small number of these have been able to secure positions which actually call for the level of training which they had had. I have talked with scores of engineering graduates who expressed various shades of dissatisfaction or even resentment over the fact that they had had practically no opportunity to make use of most of the training to which they were subjected. Between the level of the professional engineer and that of the competent mechanic there is an increasing diversity of levels of needed services. It seems to me that it would be profitable for our schools of engineering to give more thought than has been done in the past to gradations within the field, so that there could be achieved a far better adjustment of level of accomplishment and area of service to the ability and potentialities of the student. It has sometimes seemed to me that in the laudable attempt to give the finest possible training to the limited few who will be our leaders in engineering, we have forced many beyond the point where there was a clear mastery or understanding of what it all meant. It seems to me also that even higher efficiency could be reached with the talented few if we devised some way of finding an acceptable stopping place for those who do not by nature belong in that class. If this could be done without stigma of failure, we would have, in my opinion, happier

and more efficient workers in areas of engineering that do not require the possession of directing genius and yet involve fine technical performance. Similarly, in various lower grades of requirement above that of merely a skilled mechanic, there might be levels of approved efficiency corresponding to similar positions of responsibility in industrial and executive work. The happiest and most satisfactory worker is the one who feels that he is using most of the knowledge which he possesses in that field and has not been subjected to an arduous discipline that has slight connection with his duties. More important still is the probability that many valuable workers at such levels are not now receiving proper attention because they do not seem to qualify for the long struggle toward the very top of the mountain.

After thus expressing the belief that such readjustments should be brought about in the field of engineering education to a greater degree than is now true, I should like to make a realistic return to conditions as they now exist. Just as engineering processes must be differentiated to correspond with the grade of ore with which the work is concerned, so the effective teacher will adapt the approach, the exercises, and the illustrations to the ability and background of the students concerned. Sometimes the traveler who goes farthest is not the one who travels fastest in the early stages of his journey and the wise teacher will remember this, seeking clarity and mastery rather than merely speed and illusory coverage.

Perhaps in this discussion I have overworked the analogy of engineering and teaching. If I have secured some measure of sympathetic attention to the responsibilities of the teacher for utilizing the thoughtful, resourceful procedures of the engineer, I shall have accomplished my purpose. Among the various types of men who have won my keen admiration there are two: one is the patient, realistic engineer who takes into account the materials with which he has to work and the obstacles which he may have to encounter, and ultimately achieves the marvels which stir the admiration of mankind: the other is the patient, resourceful teacher who recognizes the imperfections of his human material and yet develops strength where strength is needed and guides the learner through the difficult steps of mastering a great field of learning until the product of his work appears as an individual of trained intelligence, capable of producing those more spectacular achievements which take material forms.

TRAINING FOR INDUSTRY

By GEORGE J. DAVIS, JR.

Dean, College of Engineering, University of Alabama

Engineers have played a prominent part in the development and organization of modern industries as well as in the mechanization of factories. Many of them have displayed unusual talent also for organizing the workers and managing the production of goods. In fact, it appears that engineers, as a class, have been better qualified than any other group of men to direct the operation of those industries which are based on chemical and physical processes. Men with engineering talent and training have been best qualified to devise the new techniques involved in the operation of new processes and new machines and to train operatives in their use.

Because engineers have so often and so successfully devised systems of management and directed industrial processes and organizations these actions have come to be thought of, by many, as engineering functions.

Functional Divisions of Industry

The techniques which have been developed in the various departments of modern industries are so diverse as to require a great multiplicity of specialists for their application. Indeed in any single industry the range of activities is too broad to permit an individual to become proficient in more than a few of them. No one possesses the range of talent or is so versatile in skills as to be competent and proficient in such dissimilar technological functions as research, design and development, production, marketing, fostering favorable industrial and public relations, accounting and financing, all of which are incident to the operations of modern industries.

The first of these functions may lead far into the fields of pure science and even when the research falls in the field of applied science the methods, the attitudes and the talents of the scientist are essential to its successful prosecution. Design and development are the prime functions of the engineer. Production is the basis of industry, its only justification. It involves the securing of raw materials, and processing them into finished products, as well as the organizing and management of the skilled and unskilled

personnel necessary for performing the various operations. In many industries the marketing of the products requires a personnel chosen from men with a considerable amount of talent and training in science and engineering for which the usual commercial training is inadequate. The products of many other industries do not require technical knowledge for their effective presentation to consumers and may therefore be distributed by salesmen who have had the commercial type of training. Public relations may be handled by administrative officers who have risen in the industry from either the production department or the commercial divisions of the company, but the accounting and financing belong logically to the commercial division. It may be seen, therefore, that although there is no sharply defined separation between the various technological functions nevertheless they may be roughly grouped under the four general divisions of science, engineering, industry and commerce. Not only is special training and special knowledge required for each of these fields of activity, but special talents as well.

This fact does not seem to have been appreciated by either industrial executives or engineering educators. There has been a demand on the part of industrialists for graduates having talent and training for the technical phases of engineering and who also have the characteristics and training which would qualify them for executive positions.

Engineering Training versus Industrial Training

Constantly increasing pressure is being brought on the engineering schools to lengthen the time devoted to engineering training, to provide a broader and more general education, to lay greater emphasis on mathematics, chemistry, physics, and economics, to instill in the students a more thorough grasp of statistical information, to develop a personal attitude of safe operating practices and to include numerous specialized courses. These impossible demands and the confusion of ideas as to the proper content of an engineering curriculum are due to our failure to recognize the fact that the engineer and the industrialist have fundamentally different functions to perform, notwithstanding the fact that both are dealing with industries based on the chemical and physical sciences.

Adequate provision has been made by the liberal arts and engineering colleges for the training of research scientists for the service of industry. The curricula of the engineering schools have been adequate for the training of engineering technicians. Schools of commerce provide training which fits their graduates for the accounting and finance departments of industries and the marketing

of many types of products. No school, however, other than the University of Alabama (so far as the writer has discovered), has provided a curriculum especially designed to train personnel for the heavy industries. General engineering curricula, industrial engineering curricula, administrative engineering curricula, and similar curricula which have been offered by various colleges have apparently been intended to meet this need, but have been defeated in their aims by virtue of the fact that in all cases the first two years have been patterned after the engineering curricula. Young men who wished to prepare for industrial careers have found it necessary to enroll in engineering courses, since such courses seemed most nearly to fit their needs. This has been unfortunate for several reasons. Many excellent young men who possess the social graces, executive talent, and an interest in the social and political relationships incident to the operation of large industries have been discouraged or forced to discontinue their education because they were unable, or lacked the interest, to master the advanced mathematics or technical courses which are essential to designing engineers, but which are of limited use in industry. On the other hand, while pursuing more studies of scientific and technical nature than are needed, time has been consumed which could, to better advantage, have been devoted to subjects especially needed by the industrial type of student.

It has been stated that 75 per cent of engineering college graduates eventually engage in some form of administrative work. If this is so then certainly more attention should be given to planning educational programs to meet the especial needs of this great class of men. Should we not distinguish between engineering and industry? Should we not give different types of training to prepare young men for service in these diverse kinds of activities? Instead of trying to cram into one curriculum all the courses which will train students for activities having two distinct techniques it would be better to design two separate groups of curricula, each adapted to the needs of the different fields of work. This division of the fields would not have the effect of narrowing the training for either. Relieving students in either curriculum from the necessity of specializing in the techniques of the other would provide all with more time to devote to general, broadening and humanizing studies.

Training for industry should not differ radically from training for engineering. Graduates from each curriculum should have a knowledge of the chemical and physical sciences, familiarity with engineering techniques and with industrial methods, and an understanding of human nature. But the emphasis should be placed differently in the two categories. For the engineering student the

emphasis should be placed on the development of competence in the use of chemical and physical laws, data and technique, and in mathematical analysis and computation. For the industrial student the emphasis should be placed on the development of competence in industrial economics, in social understanding, and in the interpreting of financial data. Both groups need to develop competence in graphical representation, in written and spoken English and in meeting ethical and personal problems.

With such equipment graduates from the curricula for either engineering or industry would be prepared to enter their chosen fields through the industrial arts, or so called subprofessional vocations, of drawing, surveying, shop work, or other similar lines of work, while the students of industry would be equipped also to begin their careers in the sales, personnel, or accounting departments. Therefore, the present programs for training new employees need not be modified by the larger corporations in order to train the graduates of an industrial curriculum.

If such a program were followed the students trained in the industry course would in no sense be considered engineering tyros, notwithstanding the fact that their curriculum would be largely based on the sciences of chemistry and physics and the further fact that a considerable amount of the elements of engineering theory and technique would be included in their instruction. Only relatively brief courses in the science and engineering fields would be given these students, but this is not the prime reason why they should not be considered as qualified for engineering work. If proper vocational advice and guidance are given prospective college students and only those who have talent for industrial work are allowed to register for the industry course, it will be found that those students will in general obtain only a superficial knowledge and understanding of engineering theory and technique. The industry graduates will in many cases, however, have a broader and more general understanding of engineering and its relations to industry and society than the students trained for engineering careers. On the other hand only a boy with a flair for engineering can grasp the details and fine distinctions in engineering science and practice which are so essential to safe design and for successful practice of the engineering profession.

For these reasons the graduates of the industry course should not receive the degree of bachelor of engineering or bachelor of science in engineering, but should, rather, have a distinct degree such as *bachelor of industry*, which would have a counterpart in the bachelor of commerce or bachelor of science in commerce degree. Industry students are to be trained to begin their careers most

favorably by working under industrialists rather than under scientists or engineers. The degree of bachelor of industry seems, therefore, to be entirely appropriate. It would help to establish the distinction between engineering and industry and to win early recognition of the new vocation of *professional industrialist*.

If it were clearly understood that the various engineering curricula are not intended to train for industrial pursuits, but rather for the design and the operation and maintenance of structures and machines it would be possible to modify the engineering curricula to include more training in the aesthetic and economic phases of engineering design and to make engineers more aware of the social implications of their work.

A Curriculum in Industry

In an attempt to meet the requirements outlined above the following curriculum has been designed as a course of training for a career in industry. It was offered for the first time, in slightly different form, in the fall of 1939 by the University of Alabama.

	Hours Credit	
	First Semester	Second Semester
Freshman Year		
Chemistry 1E–2E: general chemistry	4	4
Drawing 1:2: mechanical and machine drawing	3	3
Economics 1:2: American economic system, principles of economics	4	3
English 1E–2E: English composition	3	3
Industry 3: machine tool laboratory		2
Industry 21: industrial history	1	
Mathematics 1E:2: algebra, trigonometry	3	3
Military 1A:2A: coast artillery unit	1	1
Sophomore Year		
Accounting 1E–2E: industrial accounting and costs	3	3
Economics 12: labor problems	3	
Industry 2:14: wood working laboratory, int. to industrial organization	1	3
Mathematics 11:12: analytic geometry and calculus	3	3
M. E. 10: mechanism and machine design		3
Military 3A:4A: coast artillery unit	1	1
Physics 5–6: analytic physics	4	4
Physics 25–26: experimental physics	2	2
Surveying 1: elementary surveying	2	
Junior Year		
Economics 102E: engineering economy		2
E. E. 1:2: electrical machinery	3	3
E. E. 4: electrical laboratory		1
English 22E: public speaking		2
English 5E or military 6A: English literature or coast artillery unit		3

(*Continued on following page.*)

	Hours Credit	
	First Semester	Second Semester
English 104E or military 5A: technical English or coast artillery unit	3	
Industry 101: jurisprudence	2	
Industry 107: production planning	3	
Industry 109: motion and time study	3	
Mechanics 110: fluid mechanics		3
Mechanics 111:112: mechanics, strength of materials	3	3
Options	3	3
Senior Year		
C. E. 107: theory of structures	3	
Industry 103: industrial safety	3	
Industry 113:114: job analysis, cost finding	3	3
Industry 115:120: factory planning and layout, industrial economics	3	3
Industry 152: inspection trip		
M. E. 109: thermodynamics		3
M. E. 111: mechanical laboratory		2
Options and electives	6	7

For the purpose of comparison, the curriculum in industry has been analyzed and tabulated below along with the Alabama curricula in industrial engineering and mechanical engineering. From this table it may be seen that the three curricula differ only in minor degree in the fields of liberal arts and industrial arts and technique.

The two engineering courses give practically the same emphasis to natural science. The industry course naturally gives less emphasis to natural science because its graduates are not expected to make direct and specific use of natural science.

On the other hand the industry students are given more than three times as much work in industrial science than are the mechanical engineering students and considerably more than the industrial engineering students.

In the field of engineering the mechanical engineering students are given more than twice as much work as are the industry students and nearly twice as much as the industrial engineers.

A student who has completed the requirements for the bachelor's degree in mechanical engineering can, in an additional year of work, complete the requirements for the degree of bachelor in industry. The reverse is not possible.

From the above it appears that, in comparison with the mechanical engineering curriculum, the industrial engineering curriculum gives rather inadequate preparation for engineering work. This criticism applies equally to industrial engineering curricula at other institutions.

The industry curriculum frankly does not prepare for engineering work, but does prepare more adequately for industrial pursuits.

	Industry	Industrial Engineering	Mechanical Engineering
Liberal Arts			
English	12*	12*	12*
Public speaking	2	2	0
History	1	1	1
Economics	12	12	9
	27	27	22
Industrial Arts and Techniques			
Mechanical drawing	6	8	8
Shop	3	3	5
Surveying	2	2	2
	11	13	15
Natural Science			
Chemistry	8	8	8
Mathematics	12	19	19
Physics	12	12	12
Mechanics	6	10	12
Hydraulics	3	4	4
Metallurgy	0	3	0
	41	56	55
Industrial Science			
Accounting	6	6	0
Industrial organization	3	3	3
Labor problems	3	3	0
Motion and time study	3	3	0
Job analysis and cost finding	6	0	0
Production planning	3	3	0
Safety	3	3	0
Jurisprudence	2	2	2
Military science	4	4	4
	33	27	9
Engineering			
Machine design	3	6	6
Structural theory and design	3	3	6
Factory layout	3	3	0
Heat engineering	5	5	21½
Electrical engineering	7	7	8½
Water Power engineering	0	0	2
	21	24	44
Electives and options	19	5	7
	152	152	152

* Those who elect advanced military may reduce the English to 6 semester hours.

PLACEMENT SERVICE*

By A. S. LEVENS†

Director, Placement Service

During the past decade many universities and colleges have witnessed a growing need for placement services. Especially is this true of the last five years. Industry has found that it pays dividends to send representatives to the schools to recruit candidates for positions in their companies. In our own experience (at Minnesota), 20 representatives visited in 1936; 61 in 1937; a peak of 103 was reached in 1940; and a new high of 138 in 1941. Without question, the impetus given to our defense program resulted in a mad scramble for technically trained men. Not so many years ago, we considered ourselves quite fortunate if a company made two or three offers. Last spring a number of the larger firms, such as General Electric, Westinghouse, Goodyear Tire & Rubber, Pratt and Whitney, several aircraft companies, and others made 15 to 25 offers at a number of the larger engineering schools. In several fields the demand for men far exceeded the supply. This was particularly true in aeronautical, mechanical, civil, and metallurgical engineering. The demand for electrical and chemical engineers also was good.

During the past few months industry's representatives have continued their search for new recruits. Many schools will be prepared to render effective service to both industry and the graduating senior, others will not.

It is well to point out that an effective service is something more than the mere posting of an announcement that company XYZ will have its representative on the campus next Monday and Tuesday to interview those who might be interested in a position. It is much more than an "employment bureau" which in several instances is only interested in the number that is placed. In a few cases the director has refused to schedule a student for a second interview because he rejected the first offer. An effective placement service is more than a one man job. In a larger sense all members of the faculty are personnel officers. The bewildered

* Presented at the meeting of the Pacific Southwest Section, Fresno State College, December 29 and 30, 1941.

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student—yes—the confused graduating senior needs our help. Many of us have been confronted by the senior who says "Professor, I have three offers from good companies. I don't know which one to take. One company insists upon an answer within the next two weeks. Gee, I don't know much about these companies. What should I do?"

If this situation existed in 1933 most of us would not hesitate to tell the student to grab the first job he could get. Today we find that the better students receive several offers and the others at least one. Some faculty members will contend that it is the student's problem and that he should settle it. He will be faced with many problems during his lifetime and he might just as well learn to make his own decisions now. While there is some merit in this contention, nevertheless, the experience of a number of schools shows that a well organized placement service can render service to the student in a manner which will frequently lead to an easier solution of his difficulties. Certainly, our schools should lend a hand in marketing their product. Please understand that the program which will be described is not a panacea for all placement problems, nor is it spoon-feeding in character.

In the first place, thought should be given to the matter of having a centralized or decentralized system, or perhaps a combination of the two. In a number of the smaller schools, the centralized system has been quite effective. A faculty member who works well with the students and company representatives is selected to do the whole job—arrange for interviews, maintain records, counsel students, carry on correspondence, etc.

In the larger schools, placement, frequently, is a departmental responsibility. Each department has its placement officer who carries out the usual duties mentioned above. There is much duplication of effort under this system. It is also annoying to the company representative who must make arrangements with five or six departments. In some cases it creates petty jealousies between departments. At one school the situation became quite serious. The head of one department refused to send his students to be interviewed in a room which was located in a building largely occupied by another department. We (Institute of Technology, University of Minnesota) have found that a combination of the centralized and decentralized systems is most effective. Under this arrangement the Director of Placement Service is responsible for the following activities:

(1) *Maintaining Up-to-date Records.*—The practice in a number of engineering colleges includes the preparation of rating charts, personnel sheets, and frequently a complete record of student ac-

tivity throughout his college career. It also includes alumni follow-up.

The personnel sheet has met with considerable success. These sheets serve a four-fold purpose.

(*a*) They are convenient for student use in making contacts with prospective companies.

(*b*) In normal times the sheets are used in the preparation of booklets which are mailed to a selected group of companies.

(*c*) They simplify the interviewer's task.

(*d*) They serve as definite aids to faculty members who are called upon to write letters of recommendation; especially helpful in those cases where the faculty member just can't remember which Johnson, Olson, Carlson or Swanson he had in 1938. (At Minnesota this is a problem.)

(2) *Further, the Director is responsible for the Interview Arrangements,* which include:

(*a*) Preparation of time schedules, and
(*b*) Provisions for adequate interview rooms.

(3) *Arranging for Luncheons.*

(*a*) This affords an opportunity for faculty members to become acquainted with the company representatives and the needs of the company. Occasionally it leads to a summer job for a few professors. This should be quite helpful in keeping the faculty member in touch with new developments in industry.

(4) *Arranging for Lectures on Employment.*—These lectures and discussions are usually presented by personnel men selected from industry. Subjects which have been of benefit to the students include:

(*a*) The Letter of Application.
(*b*) What Constitutes an Interview?
(*c*) Orientation Programs of Industry.
(*d*) What Does Industry Seek in the "Young Technical Graduate"?
(*e*) Opportunities in Government Service, etc.

(5) *Counseling.*

(*a*) Interviews with graduating seniors.
(*b*) Directing students to experts in various fields.
(*c*) Presenting vocational information.

The counseling program is planned to stimulate the student to give thought to his employment problem. It is well to start this activity in the freshman or sophomore year.

(6) *Maintaining Up-to-date Material Concerning Employment Opportunities.*—We have several hundred pamphlets, and brochures which have been prepared by industry. Typical ones are: The Graduating Engineer and Ingersoll-Rand; The Loop Course, Bethlehem Steel; Engineering Training and Opportunity, Ethyl Gasoline Corporation; other good pamphlets by General Electric; Westinghouse; Goodyear Tire & Rubber; Commonwealth Edison Company; Allis-Chalmers; Aluminum Company of America, and many more. Students are urged to examine these long before the company representative visits the school. This helps the student during the interview.

Faculty participation is a vital part of the program.

(*a*) Each department has a placement officer who works in close harmony with the Director. The selection of students to be interviewed is made by the department employment committee.

(*b*) Counseling and programs which deal with employment in the various branches of engineering are carried on by the committee concerned—frequently in coöperation with student branches of the professional societies. Only two frequently faculty members are likely to label a student as "dumb" when he fails to measure up to the instructor's requirements in his course. It is easy to tell the student "You don't belong in engineering"—but it should be recognized that from a broad social point of view we render a real service only if we properly steer the student into fields which will develop his talents to the fullest degree.

(*c*) After the interviews faculty members participate in discussions with company representatives concerning the selection of men for various types of positions in the company.

Student Responsibility is a definite part of the service. The student should make it his business:

(*a*) To become acquainted with members of the faculty. He should realize that faculty members are frequently requested to express their opinions of him. The company representative knows that he cannot learn very much about the student in a fifteen-minute interview. True, he can get some impression concerning personal appearance, approach, mannerism, etc. In most cases, he depends upon records, faculty ratings, and recommendations.

(*b*) To take Inventory of Himself. I recall the case of an alumnus who, upon entering the placement office, asked, "Do you know of any openings?" "How is the job situation?" "What field of work is the best one to get into?" I asked him to remove his hat, be seated, and tell me his name, the course he had taken, and

when he had graduated. "I am John Smith of the class of '33 M.E." "What are you selling," I inquired. "I'm not selling anything. I am not a salesman. What's that got to do with a technical job?"

I then asked him the following questions: "Aren't you trying to sell your services?" "What type of work do you enjoy?" "What would you like to do?" "Have you taken inventory of your ability? of your experience? In what way does your training and experience fit you for the work you would like to do? Have you attempted to learn of the names of companies that do the type of work that you believe you could perform successfully? Have you investigated the fields which are in need of well trained engineers?"

His reply was, "Gee whiz, I hadn't thought about these things at all, I just wanted a job. I'll be back in a few days—and then perhaps you can give me some help."

We have found that the student can do a pretty good job in answering such questions as:

1. What type of technical work do you really enjoy?
2. What subjects are least interesting?
3. Are you aggressive or retiring?
4. Do you like to work with a group, or do you prefer to work independently?
5. Do you plan your work or do you operate on a hit-or-miss scheme?
6. Do you give attention to your personal appearance, or are you indifferent?
7. Do you coöperate with others, or do you cause friction?
8. Are you lazy or industrious?
9. Are you satisfied to merely "get by"?
10. Do you always depend upon others?
11. Do you ever take the initiative?
12. Are you easily tempted?
13. Can you be trusted under the most trying circumstances?
14. In what type of work do you believe you would be successful?

It is the student's responsibility:

(*c*) To attend meetings pertaining to employment.

(*d*) To use available information about the various companies, and employment opportunities.

(*e*) To make contacts with company officials. This can be done during vacations in many instances.

(*f*) To obtain summer jobs in the technical fields if possible. Economic conditions during the period 1932–1936 made this virtually impossible. Since then an increasing number of sophomores and juniors have had opportunities for summer employment.

(*g*) To maintain good scholastic records.

(*h*) To participate in extra-curricular activities.

Industry plays an important part in the placement service program. Its representatives should

(*a*) Understand college students;

(*b*) Know how to put the student at ease;

(*c*) Know the needs of the company;

(*d*) Be capable of portraying the type of work the graduate will do, in a concise and clear-cut manner;

(*e*) Look to the faculty and placement director for detailed information concerning the student's qualifications;

(*f*) Provide the placement office with adequate information such as data and time of arrival; number of men to be interviewed; length of each interview; types of positions available, etc;

(*g*) Give the student a reasonable time to accept or reject offer, and

(*h*) Avoid high-pressure methods.

The companies that have contacted the schools for a number of years do have capable men who continue to do a grand job. It is hoped that more companies will recognize the importance of developing and retaining college recruiting programs. I recall one case where the students soured on the representative because he insisted that he could select the best men by the manner in which they entered the room, the grip of the handshake, and whether or not they looked him straight in the eye during the interview. Fortunately this individual was not retained as the company's representative very long. Quite likely he was a follower of palmistry and phrenology.

While it is true that this year's engineering graduates will have no difficulty in locating positions, we should recognize that, paradoxical as it may appear, the keenest type of competition will prevail *after* the student is on the job. When our "all-out war efforts" have reached a successful conclusion there is likely to be a curtailment in the number employed and consequently only those who have made outstanding records will be retained.

We have a very important job to do, not only in helping to place our technical students to best fit their talents but to condition them for tasks and situations which are likely to exist in a post war era. It will rest upon engineers and scientists to develop many new

products for consumer use in order to maintain a high rate of employment. We certainly do not wish to experience again the many trials that our alumni had during the period 1932–36. A period when the closest approach to electrical engineering that some graduates experienced was elevator operating; some civils who were fortunate to act as truck drivers; others who became shoe salesmen and still others social workers.

The engineers of today and tomorrow will be called upon, and I hope quite soon, to use their training and ingenuity toward the development of a flow of usable goods which will necessitate, not only the retention of those now employed, but also the absorption of those who will graduate in years to come.

The young engineer is faced with a real challenge. We who are engaged in training him can and should lend a helping hand. Let us do the best teaching job we are capable of doing. Let us do a thorough personnel job too. Both are vital parts of our teaching program; today both are vital parts of our present war needs.

THE MENTOR SYSTEM *

A PERSONNEL SYSTEM FOR ENGINEERING FRESHMEN

By A. D. MOORE

Head Mentor and Professor of Electrical Engineering, University of Michigan

During the past decade, the Mentor System has been the object of considerable interest, and many inquiries have come in concerning it. Further inquiries are to be expected, since the general movement to initiate or to improve freshman personnel work is on the upgrade throughout the country. The present description of the Mentor System was originally prepared, in part, to meet expected inquiries.

This document is not at all a brief for student personnel work, nor does it intimately describe actual details of the work. It is written for the reader who already believes that such work is vital to the life of any college; and, except for such features as may be mentioned below, actual relationships between personnel officers and students, and what goes on within these relationships, will be found in one or more of the references given in outline C, rather than in this paper.

Student personnel work may be, and is, operated in many different ways. Omitting the possibility of there being no personnel work whatever, we may think of two extremes. First, all of the work may be done by one, or a very few, full-time professionally-trained personnel officers. Or, second, all of the work may be assigned to completely untrained and unorganized faculty members. The Mentor System is neither of these. In the Mentor System, selected faculty members do the freshman personnel work, acting within an organized framework, in a plan having direction and scope. Moreover, the Mentor System has a history. It is not new, although it has long been subject to growth and improvement. For these reasons, and because many colleges may continue to find it necessary to have faculty members carry the personnel work, the Mentor System may continue to be of interest to those who are planning personnel systems, or changes in existing systems.

The Mentor System must be one of the oldest personnel programs in continuous operation. It was devised by Dean Mortimer

* Presented at the 49th Annual Meeting, S. P. E. E., University of Michigan.

E. Cooley, and installed under his supervision in the fall of 1911. Ever since then it has remained, with the full sanction and cooperation of the faculty, as a personalized form of the Dean's interest in the freshman's problem of making a proper adjustment to his new environment.

At the first meeting of the Mentors, Dean Cooley said, "The Mentor should be the elder brother and should see that every man in his group gets the largest possible benefit out of his college life." A Mentor, no matter how well equipped, cannot attain this objective working single-handed; he must have the full coöperation of the freshman himself. Thus, an important factor in the selection of a Mentor is that he be able to secure that coöperation.

A phase of Mentor activity is that of reporting scholastic standings to freshmen, twice within both semesters of the first year. Each semester is divided roughly into thirds. Soon after the first third is over, all faculty members teaching freshmen report the standings to the Head Mentor's office. These reports are handled by a fast system of posting, and the reports for each freshman are quickly issued to the Mentors. The Mentor holds interviews with his men within a prearranged schedule, and any new adjustments that seem to be needed can be recommended. Soon thereafter, copies of the reports, with a letter, are mailed to the parents. The process is repeated after the second third of the semester. These reports have long been called Mentor Reports.

The word "coöperation" is the key to much that goes on. This is especially true of Mentor Reports. These would be of little use in assisting the freshman to make rapid adjustments, unless they were promptly and completely furnished by the faculty, and promptly made available to the freshmen, in conference. For years, faculty members have given splendid coöperation in handing in their ratings of scholastic progress. This is true, even though the Mentor Report is only semiofficial. The Mentor Report is held within the Mentor System, and does not become a part of the student's official permanent record.

An important part of the Mentor's duties is his contacts with parents, personally or by mail. Many contacts arise naturally, once the parent learns there is a personnel officer available who is dealing directly with the freshman. Many more contacts develop when the reports are sent home.

It should be noted that the Mentor is without authority. The general principle is well established that, as far as possible, personnel officers should be free from the exercise of authority—in order that they may have maximum coöperation. The Mentor may recommend a course of action, but he will seldom, if ever, see that

it is enforced. The Mentor protects confidential aspects of a student's problems; his usefulness would be destroyed if he did not.

Student personnel work often suffers at the hands of its friends. Many people (including the usual parents) strongly believe in it, but know little of the limitations. They are prone to assume that we "know all the answers" to questions raised by student difficulties. We are far from having achieved that happy state. A Mentor is not selected because he "knows all the answers." He is selected for attitude, willingness to do the work, willingness to learn. As to routine matters of information, the Mentor can and does answer all sorts of questions—either directly, or by reference to others or to published information. But as to the more personal, deep-lying sources of difficulty, a given Mentor may or may not have had the experience needed to detect the real cause and to know enough to make the recommendation for alleviation or cure. In such case, he makes ready use of any services available on the campus. For example, he does not hesitate to refer a student to the Health Service or the Mental Hygiene Unit; and the freshman seldom fails to take advantage of the service.

In scholastic adjustment, the Mentor is often presented with a picture he can easily analyze. For example, a freshman is carrying a full schedule, is nearly self-supporting, and is falling down in his first reports. The solution is simple: drop some load somewhere, and drop it at once. But in some cases, impending failure as predicted by Mentor Reports cannot be analyzed at once by the Mentor, nor by anyone else within a reasonable time. The Mentor will look for emotionally disturbing factors, such as worry over an unhappy home situation; and he will help the freshman to realize that this alone may be the main cause of the difficulty. But often, no one can be sure that this is the cause, until, perhaps, the home situation clears up and the student's troubles disappear as a consequence.

The Mentor's judgment of student capacity for doing creditable work is, of course, aided by having access to all information available—such as the high school record, other items in the application blank, and performance on Orientation Period tests.

These brief remarks on the Mentors and their work would be incomplete, if they did not include a tribute to the fine work they have done and are doing. The typical Mentor puts in many hours each year, often at inconvenience to himself and to other work he might wish he were furthering. Such coöperative effort would, of course, not be engaged in, year after year, if the Mentors were not themselves convinced of the value of their services; and if, moreover, they did not find some elements of enjoyment in helping young men to reach a proper adjustment with the new environment.

Since the inception of the Mentor System, freshmen have been required to attend a one-hour weekly assembly. The assembly is in charge of the Head Mentor. Originally, programs consisted mainly of speeches by the Dean, by heads of departments, and various on-campus and off-campus speakers from engineering and non-engineering fields.

The character of the freshman assembly has gradually changed in order that it might reflect the growing body of knowledge concerning worthwhile student personnel work. This has been made possible by having a permanent Head Mentor (beginning with the fall of 1927) who could view his task in terms of its long-range aspects and plan and work accordingly. Within the last two decades a great deal of research has been done in many places. Today, there is an established set of facts concerning reasons for some types of student failures, and something is known as to remedies that may apply. Since a college is prone to place undue emphasis on rehabilitation of failing students, it should at once be mentioned that there is also a big job to be done in helping *succeeding* students to become effective at the top level of their capacities. With these things in mind, the Head Mentor has gradually built up a series of talks designed to help *every* freshman to be a more effective student in college and a more effective individual in society. Now, all but about 5 of the (approximately) 29 assembly programs are given by the Head Mentor. Outline B indicates the topics now being covered.

A survey of freshman reactions to the assembly content was made at the end of the present school year. The opinions expressed covered 27 of the programs mentioned in outline B. The totalized reaction, expressed in per cent, is as follows:

FINE	GOOD	FAIR	DROP
32	38	24	6

This reaction would seem to be sufficiently favorable, when it is recalled that the assemblies are required, with no credit given. As to the 6 per cent vote to "Drop," this is an average, or composite. Mostly, freshmen do not agree on which program to drop—which reflects the obvious fact that a given program will have different appeals to different individuals. Also the guess may be ventured that in any large freshman group, at least 6 per cent will argue against anything being required, for any purpose, at any time.

At this writing, the two outstanding needs of the Mentor System are for a more adequate training of mentors, and for having a university testing unit. The first need was partly met prior to 1932, through discussion sessions in which mentors would discuss

problems in common. Until size of faculty is increased or student enrollment is reduced, these discussions can hardly be resumed on an adequate scale; there are limits to the time given by a mentor, beyond which his effectiveness will be reduced rather than increased.

As to testing, it is somewhat expensive. Three tests are given in orientation period (see outline A); but these should be supplemented throughout the year, as occasion arises for at least some students, for testing of aptitudes, interests, etc., as well as check-tests on reading speed and comprehension.

The Mentor System may be described as a reasonably simple, reasonably effective personnel system. If the writer had been a professional personnel man, he might, during his years as Head Mentor, have bent all efforts to turning it into a professionalized—an expensive—personnel system. But, being an amateur personnel man, and having other things to do as well—he has managed to stifle such ambitions. His dominant idea has been to make all of the energy expended go as far as possible. One result is, that the Mentor System seems to be depression- and emergency-proof. It has no large budget, subject to cuts; and it has no professional workers who might seek greener pastures elsewhere.

Three outlines covering details are included at the end of this paper. These are:

Outline A—The Mentor System.
Outline B—Freshman Assembly Topics.
Outline C—Reading List for Personnel Officers.

Outline A—The Mentor System

1. History.
   - *A.* One of the oldest student personnel programs in continuous operation.
   - *B.* Devised and installed by Dean Mortimer E. Cooley, fall of 1911.
   - *C.* Since fall of 1927, same Head Mentor has served continuously; prior to that, Head Mentor was changed each year.
   - *D.* Originally, ten freshmen to a group; now, about 20.
2. Organization.
   - *A.* Mentor system administered by Head Mentor, who reports to Dean.
   - *B.* Head Mentor is contact man with other campus personnel officers and groups dealing with freshmen.
   - *C.* The Mentors are the personnel officers working directly with the freshmen in their groups.

D. Engineering freshmen (400—plus) divided into 20 groups, with a Mentor to each group.

3. Mentor System.
   A. Operates for the student's freshman year only, except—
   B. A Class Mentor is appointed for each class; he stays with his class in an advisory capacity, until it graduates.
4. Orientation Period.
   A. Is organized on a university-wide basis.
   B. Provides schedules by which routine, registration, classification, medical examination, testing, are gotten out of the way before school opens.
   C. Tests: the tests given all freshmen are, (1) American Council on Education Psychological Examination, (2) Coöperative English Test, Form PM, and (3) Nelson-Denny Reading Test.
   D. During the period, the mentor serves within the university plan, as an adviser; the next week, when school opens, he continues with his same group, as an engineering mentor.
5. Mentor.
   A. Is a personnel officer.
   B. Is selected from among those who teach engineering subjects.
   C. On the average, serves continuously for several years.
   D. Is selected and appointed by the Head Mentor.
   E. Is selected because of an intelligent, sympathetic, nonsentimental attitude toward the work to be done; willingness to assume a real burden; willingness to learn.
   F. Meets his freshmen and conducts them through orientation period; has several scheduled interviews with them in the freshman year, as well as interviews otherwise sought by freshmen; corresponds with and sees visiting parents; has any other contacts (telephone, mail, personal) with faculty members, health service, others, as may be required in particular cases.
6. Training, Compensation.
   A. In the professional personnel sense, Mentors are untrained. Up to 1932, occasional mentor meetings were held, to discuss various phases of personnel work. Due to cuts in budget and staff, increase in enrollment with consequent extra burden on the faculty, and additional time required of the Head Mentor for graduate placement work of his own department, the training sessions were dropped and have not been resumed.

New Mentors individually consult experienced mentors, or the Head Mentor, on phases of the work unfamiliar to them. The Head Mentor will cover certain items in occasional letters to the Mentors.

In brief, the Mentor's training is "in-service" training.

B. The Mentors are not given extra compensation. The theory is that, in a large college, there are many things to be looked after aside from teaching. Faculty members will always carry the extra duties of standing and special committees, mentor work, placement work, and so on. It is up to the Mentor and his department chairman, to reach a proper adjustment of load.

7. Mentor's materials. In dealing with the freshman's various problems of adjustment, the Mentor has, or has access to, the following information or sources:
   A. Mentor reports (described later).
   B. Orientation Period Tests.
   C. The application blanks (with high school record, principal's recommendation, etc.).
   D. Semester grade reports.
   E. Mentor Book.
   F. Instructors of freshmen.
   G. Parents, by letter and in person.
   H. University health service.
   I. University mental hygiene unit.
8. Interviews with freshmen.
   A. A number of interviews in orientation period.
   B. Regular interviews, scheduled, twice within each semester, and at the end of the first semester.
   C. Extra interviews, as sought by freshmen or arranged by mentor.
   D. Interviews based on mentor reports come twice within each semester.
9. Classification.
   A. By "classification" is meant the actual assignment of the student to his scheduled subjects. This is done by regular classifiers, not Mentors. However, before each semester, the Mentor determines whether a freshman shall classify early or late, and makes such recommendations as may be called for.
10. Mentor Reports.
   A. Mentor reports are reports on scholastic standing, made by teachers of freshmen, through the mentor system, to the freshmen and others.

B. They are collected from the faculty in the 6th and 11th weeks of school; issued in the 7th and 12th weeks.

C. The freshman receives his copy during a scheduled interview.

D. Symbols for reporting are

I. Grade: A, B, C, D, E.

II. Progress rate: 1, Rapid improvement.
2, Slow improvement.
3, No change.
4, Growing worse.

III. Difficulty: *a*, Home work.
b, Lab., drawing room or shop.
c, Written examination.
d, Class work.
e, Work not up to date.
f, Previous preparation.
g, Absences.
h, Health or vision.

E. Use of the additional symbols: The Progress Rate and Difficulty symbols were adopted about twelve years ago, and they are widely used. An actual report, from five different instructors, on a freshman in five subjects is as follows: E4ac; C3f; C; E3cd; De.

F. Predictive value of extra symbols: A study made some years ago showed that if both reports in a subject were plain D, the final grade would be C in over half the cases; but if both reports were D, each accompanied by two Difficulty symbols, the final grade would be E in over half the cases.

G. Instructors' reports: Blanks are sent out to instructors; a class section is reported on each blank. To save the instructor the work of copying his names from classbook twice, the same blank is returned to him for the second report.

H. Posting: Freshmen are alphabetized on 8 by 5 cards in a visible filing system. The reports are posted on the card, for office record; and at the same time, on inserted slips.

I. Copies of reports: At first, only one slip was inserted, and this copy went to the mentor. Then an extra slip was inserted a few years ago, to make a copy to send to the parents. In 1939 a re-design was effected in terms of using a packet of carbon-backed slips. Thus four copies on slips are produced at one writing.

J. Copies go to: (1) the mentor; (2) the freshman through mentor interview; (3) the parents; (4) the advisory system of the new university residence halls.

K. Blanks used: May be secured by writing to the undersigned.

L. Speed: Within a period of about ten days, the reports are secured, posted, sent to mentors, and are used for the basis of interviews.

M. Completeness: Typically, the reports are better than 95 per cent (on time) complete; typically, interviews are held within scheduled period of two to three days, to extent of 95 per cent.

11. Value of Mentor Reports.

A. Early reports on scholastic performance, speedily made available and used in interviews, frequently furnish the only basis on which early adjustment of schedule or outside interferences can be effected.

B. Parents: By sending reports home (accompanied by a letter) numerous mail and personal contacts with parents are opened up. These are often of very considerable value. Even when the parent can contribute nothing, or when there are no problems of adjustment, the inclusion of the parent in this manner in the personnel picture adds greatly to the parent's peace of mind—as numerous letters testify.

12. Clerical. During the year, about one-half of the time of a stenographer in the Dean's office is used on the clerical work of the mentor system.

13. Cumulative Personnel Records.

A. Among college personnel officers, nationally, some emphasis has been given in recent years to the idea of having cumulative records of some kind. The mentor system operates only through the freshman year, while the freshmen are undivided, and before they become departmentalized as sophomores. In the general sense, mentor system records do not as yet become the early records in a cumulative record system.

B. Plans: The College of Engineering recently adopted a uniform but departmentalized system of personnel records for all students above the freshman level. It is to be expected that some of the mentor system records, in old or new form, will carry over. The carry-over is not yet worked out.

14. Mentor Book: A looseleaf notebook (8.5 by 11) is issued each year to all mentors. By means of simple forms, the mentor is able to keep his own records of interviews, mentor reports, and significant items with respect to particular freshmen.
15. Freshman Assembly.
    A. Weekly, throughout the year, one hour, no credit.
    B. Attendance compulsory.
    C. Until 1938–39, one section; then and thereafter, with too large a class for the assembly room, run in a morning and an afternoon section.
    D. Purposes: See outline B.
    E. Handled by Head Mentor, who gives most of the talks. These talks (most of them) have been carefully built up over a period of years, and extended as more material became available. Copies of these talks are not available; notes are used, and the talks have not been reduced to written form.
    F. Topics: Given in outline B.
16. Head Mentor.
    A. Is a staff member of an engineering department.
    B. Administers the mentor system.
    C. Selects and appoints mentors.
    D. Has charge of assembly, gives most of the talks.
    E. Is consulted by individual mentors on difficult cases.
    F. Is seen by many freshmen throughout the year, as to individual problems.
    G. Acts frequently as reference man, for freshmen, mentors, parents, faculty members, others.
    H. Handles placement of seniors and graduates of his department—thereby gaining valuable experience useful in freshman personnel work.
    I. Member of American College Personnel Association.
    J. Keeps continued watch for published material of interest in personnel work, or of value in improving or adding to assembly talks. (See outline C.)
    K. Maintains a number of contacts with industry, personnel groups on and off the campus, with personnel men in college and industry.
17. Studies. Because all freshmen are available weekly, it is easily possible to make occasional studies, formal and informal.
    A. For two years, a faculty committee has given an extensive questionnaire on freshman subjects—as to teaching methods, texts, course organization, etc.

B. The Head Mentor makes occasional studies, such as: scope of freshman reading; extent of fears and worries; expectation of securing summer work; reaction to assembly programs.

Outline B—Freshman Assembly Topics, 1940–1941

The content of 29 weekly assemblies is covered in this list, which presents a general guide to content. Actual arrangement, sequence, and specific content are all subject to annual revision.

A majority of the talks are given by the Head Mentor. These talks have been subject to re-arrangement and improvement for a number of years. They are not available in written form.

Topics

(The order of listing below is not the order in which talks are given.)

A. For Integration with the College and University.

1. General talk on assembly content for the year. Explanation of the mentor system.
   The Engineer and Defense:
2. Dean Crawford.
3. Alumni Secretary T. Hawley Tapping; Michigan Technic editor.
4. Sigma Rho Tau (stump speaker society). The Honor System.
5. General: home list; transfers; dropping out; classification.

B. For Adjustment to Performance to College Level.

1. Scholarship vs. Later Success. (Bridgman, Bell Tel. Study.)
2. Computing: Slide rule: time-saving with slide rule.
3. Slide rule: Voluntary session, log scales (several out-of-class-hour voluntary sessions on practice with the rule are held—well attended).
4. Note-taking, outlining, notebook sizes.
5. Student use of time: Dean Crawford.
6. Fatigue: Related to study habits, work methods, examinations.
7. Psychological Laws of Learning. Pavlov's experiments. Stimulus-response bonds. Law of Sequence. Law of Simultaneity. Illustrations.
8. Laws of Learning continued. Old and new stimuli. Old and new responses. Vocabulary. What we learn are the *reactions* we make. Making outlines—and react-

ing. Rate of Learning; Vigor of Learning; illustrations. Good paper work as related to all this. Law of Specificity, and its relation to our failure to generalize.

9. Laws of Learning continued. Expansion of previous material. The chemist, and his remarkable fund of information: how he comes by it (by working with the real stuff), and the relation of this to good study techniques. Illustrations.
10. Learning and Forgetting; the "preliminary once-over" mode of attack; active vs. passive study attitudes.
11. Reading and study techniques. Preparing for final examinations.

C. For Personal Growth and Social Integration.

1. Student fears and worries; what to do about them.
2. Personality development. Rich and poor personalities.
3. Summer work: How to get it.

D. For Integration with Engineering.

1. General: A. M. Dudley, of Westinghouse.
2. Incomes: the engineer's economic place in society.
3. Functional divisions of the engineer's work.
4. New developments (as, Fiberglas, Polaroid, Superfinish, etc.), as background for discussion of invention, research, development, etc.
5. Invention: Striking examples of important inventions *not* made by those who would be expected to make them; why we fail to invent (one reason: Law of Specificity); facilitating invention.
6. Inventions and patents. The minimum facts presented.

E. For Development of Engineering Working Methods and Practices.

1. Paper work: good standards.
2. Graphics: Good standards and practices.
3. Similarity: some laws of similarity, and applications.

F. For Improvement in the Freshman Assembly Programs.

1. Survey of freshman opinion of the programs; request for suggestions leading to improvement.

Outline C—Reading List for Personnel Officers

Effective Study Methods

1. "How to Study," A. W. Kornhauser, The University of Chicago Press, 4 by 6 booklet, 43 pages.
2. "Effective Study Habits," Charles Bird, D. Appleton-Century Company, 247 pages.

3. "Students' Guide to Efficient Study," Cole and Ferguson, Farrar and Rinehart, 38 pages.
4. "The Learning Process; and the Principles of Teaching," Grover H. Alderman, April 1929 JOURNAL OF ENG. EDUCATION.
5. "Laws of Learning," Walter F. Dearborn, January 1929 JOURNAL OF ENG. EDUCATION.

Orientation

6. "Marketing Industrial Equipment," Bernard Lester, McGraw-Hill Co., 307 pages.
7. "Life Earnings in Selected Occupations in the United States," H. F. Clark, Harpers, 408 pages.
8. "Engineering—A Career, A Culture," The Engineering Foundation, 61 pages.
9. "Preparation for Seeking Employment," Howard Lee Davis of N. Y. Telephone Co., reprint from Nov. 1935 JOURNAL OF ENG. EDUCATION, 15 pages.
10. "Building an Engineering Career," C. C. Williams, McGraw-Hill Co., 247 pages.

Development of Effective Engineering Working Methods and Practices

11. "Engineering Problems Manual," Dana and Willmarth, McGraw-Hill, 313 pages.
12. "Report of the Conference on Orientation and Engineering Problems Courses" (Reprint from May 1939 JOURNAL OF ENG. EDUC.), 22 pages.
13. "Graph Sheets," Keuffel and Esser, 32 pages.
14. "Figuring with Graphs and Scales," Herbert G. Smith, Stanford University Press, 62 pages.

Mental Hygiene

15. "A Student's Dictionary of Psychological Terms," Horace B. English, The Antioch Press, Yellow Springs, Ohio, 84 pages.
16. "In the Name of Common Sense," Matthew N. Chappel, MacMillan, 192 pages.
17. "Adolescence," Frankwood E. Williams, Farrar and Rinehart.
18. "Discovering Ourselves," Strecker and Appel.
19. "Just Nerves," Riggs.
20. "Intelligent Living," Riggs.
21. "The Psychology of the Unadjusted School Child," John J. B. Morgan, MacMillan.
22. "A Study of Undergraduate Adjustment," Robt. C. Angell, The Univ. of Chicago Press.

23. "A Mind that Found Itself," Clifford Beers.
24. "The Human Mind," Karl A. Menninger, Alfred A. Knopf, 447 pages.
25. "The Mind in the Breaking," Haven Emerson, *Survey Graphic*, Jan. 1931.
26. "Outlines of Psychiatry," William A. White, Nervous and Mental Disease Publishing Co., Washington, 445 pages.
27. "Lecture Series for 1929," Colorado Society for Mental Hygiene, Dr. Arthur H. Ruggles, Yale University, 57 pages.
28. "The Psychiatrist in the College," Winifred Richmond, *Journal of The Amer. Assoc. of Univ. Women*, April 1929.
29. "Some Social Aspects of Mental Hygiene," May 1930 Supplement of *Annals of Amer. Academy of Political and Social Science*, 3622 Locust St., Philadelphia, Pa. Edited by Frankwood Williams. A fine set of papers.

General

30. "Report of the Sixteenth Annual Meeting of the American College Personnel Association," February 1939, 203 pages.
31. "Student Counseling at the University of Minnesota," Booklet of 24 pages (obtained from the Registrar).
32. "Success in College and Business," Donald S. Bridgman (A. T. & T.). Reprinted from June 1930 *The Personnel Journal*, 19 pages.

A PRESENT DAY TRANSPORTATION CURRICULUM *

By JOHN S. WORLEY

Professor of Transportation Engineering, University of Michigan

The impact of a rapidly changing world is not confined to business and politics but is felt by every social group. The field of education is probably affected more by these rapid changes than elsewhere. This is particularly true due to the fact that in order to keep abreast of the most modern trends the educators must anticipate and prepare their work to coincide with these social changes as they come along. It is by the preparation of new programs and curriculums that educators are able to meet the needs of changing conditions. It is probably because of this foresight that educators are sometimes accused of being radical or ultra-socialistic. Engineering participation in the early transportation enterprise in this country was confined entirely to design and construction of these properties. These were designated internal improvements which included highways, toll bridges, canals, and harbor and river improvements.

Those active in these early enterprises were such engineers as Claudius Crozet, B. H. Latrobe, William Weston, originally citizens of Europe where they were educated, and Loammi Baldwin, Stephen H. Long, George Washington Whistler, William Gibbs McNeill, John B. Jervis, William Strickland, Robert Mills, Horatio Allen, James Geddes, Benjamin Wright, Jonathan Knight, John A. Roebling, Charles Ellet, and Edwin F. Johnson. Of these John A. Roebling received his engineering education at the Royal Polytechnic School in Berlin and Charles F. Ellet spent one year at the Ecole Politechnique in Paris. Most of the others received their training as members of the Engineering Corps of the United States Army.

The first engineering school organized in this country was the Military Academy at West Point, which was founded in 1802 but as far as we have been able to ascertain, no courses were taught dealing with the construction of internal improvements until probably 1823, at which time in the course in Civil and Military Engineering was included material on the Construction of Canals. It appears that some railroad instruction may have been given as early as 1827.

* Presented at the 49th Annual Meeting, S. P. E. E., University of Michigan.

In this connection it is interesting to note that the American Literary, Scientific and Military Academy at Middletown, Connecticut, as early as 1827 offered a course in canal and railroad construction which was taught by Edwin F. Johnson, of whom mention has already been made.

The next engineering college to be established in this country was that of Rennselaer which was founded in 1824, although as far as can be ascertained no courses in the construction of canals or railroads were offered until 1837. In 1846 the universities took up the matter of technical education at which time was founded the Sheffield Scientific School at Yale and the Lawrence Scientific School at Harvard.

The Engineering Corps of the United States Army came into being June 6, 1775, and in 1778 General Washington in an order issued from Valley Forge on June 9, had this to say: "As the Corps will be a School of Engineering it opens a prospect for such gentlemen as enter it." It appears reasonable to say that in general the engineers in the United States who were engaged in their profession as of 1830 were either natives of Europe who were educated there or received their engineering education as members of the United States Engineering Corps.

Following the establishment of engineering schools at Harvard and Yale in 1847, other universities created such departments, schools or colleges. By the latter part of last century there was not a state in the Union but what had one or more engineering schools, all of which contained courses in the design and construction of our various transportation facilities. However, these applied primarily to the construction of railroads in that from 1830 to 1900 our railroads had their principal growth and were our principal transportation agency. The railroads held the position of being almost a monopoly in internal transportation until 1920.

Engineering education up to and including the early part of the present century was of the most technical nature with a strong tendency towards extreme specialization. In the transportation field the curricula consisted of studies of the designing and construction of the railroads. Even though the education of engineers was confined to this narrow field, executives of railways and other forms of transportation found that when these persons were given executive positions, the results were quite satisfactory. Out of this has developed the recognition that there is a large field for engineering employment with transportation companies in addition to that of the more technical engineering nature.

Recognizing this situation the Engineering College of the University of Michigan established the Transportation Division of

Civil Engineering. The faculty members who are made responsible for this work have been engaged in the development of a curriculum and a study of the value of the services of those students who have thus specialized.

The present transportation curriculum consists of three parts. The first, being preparatory courses, contains those fundamentals upon which all engineering education is predicated, mathematics, engineering mechanics, physics, chemistry, drawing and the proper use of English. In addition, there are nine hours of economics, including accounting, three hours of non-technical electives, making a total of 66 hours. In the second part, designated secondary courses, there are 51 hours which include courses in surveying, engineering mechanics, mechanical engineering, electrical engineering, and transportation engineering in an amount of 51 hours. Parts one and two are required of all transportation students. Part three, professional options, is subdivided into five parts, railroad, highway, automotive, aeronautic, or marine engineering, each being 23 hours. These subdivisions permit the student to major in that field in which he is particularly interested. The curriculum has a total of 140 hours. The curriculum is conceived with the idea of giving the engineer sufficient technical training that he may pursue engineering in that branch of transportation he has elected, and at the same time includes sufficient courses in economics, English, regulation and other subjects which are so much a part of the transportation executive's work, that it is possible for him to pursue executive work in his particular chosen field.

The curriculum in the Division of Transportation is as follows: The credit hour is equivalent to one hour recitation per week for a semester of eighteen weeks, including examinations.

	Hours
(a) Preparatory Courses	
English	10
Mathematics	16
Physics	10
Chemistry, including Materials and Shop Work	10
Drawing	8
Economics, including Accounting	9
Non-technical Electives	3
	66
(b) Secondary Courses	
Surveying	6
Engineering Mechanics	11
Structures, Steel and Concrete	10
Contracts and Utility Problems	4
Highway Engineering	2
Railroad Engineering	2

Design of Rail, Bus, Truck, Water, and Airport Terminals	3
Transportation Administration	3
Coördination of Transportation	2
Mechanical Engineering	4
Electrical Engineering	4
	51

(*c*) Professional Options (one group to be selected)

1. Railroad

Technical R. R. Courses	9
Electric Railways	2
Electives	12
	23

2. Highway

Technical Highway Courses	11
Internal Combustion Engines	3
Electives	9
	23

3. Automotive

Technical Auto Courses	15
Electives	8
	23

4. Aeronautical

Technical Aero Courses	9
Advanced Mathematics	3
Electives	11
	23

5. Marine

Technical Marine Courses	13
Electives	10
	23

In conjunction with the above curriculum are field inspections, library reading and minor research projects of a character in keeping with the student's ability.

Our experience with the foregoing curriculum and a study of the operation of our transportation agencies leads us to the inevitable conclusion that there lies immediately ahead a very important area in education which will be of great benefit to the student and give to our transportation agencies a field from which to recruit better trained young men.

ENGINEERING ECONOMY PAGE

Engineering Economy deals with comparisons between technical alternatives in which the differences between the alternatives are expressed as far as practicable in money terms.

PAUL T. NORTON, JR., Virginia Polytechnic Institute, *Editor*

As his very first action, the new editor of the Engineering Economy Page requests the assistance of all who are interested in the subject. Please send him your suggestions, with regard either to general policy or specific subjects which you feel should be discussed. For the time being, the Page will consist of problems which illustrate various aspects of the general subject of Engineering Economy with which students seem to have difficulty. Please send the editor problems of this sort which you think would be helpful to other teachers of the subject, and please also send your suggestions with regard to the best methods to use in class in explaining the problems which we shall publish. Please write direct to Paul T. Norton, Jr., Virginia Polytechnic Institute, Blacksburg, Virginia.

(The following problems are adapted from the problem book of "Principles of Engineering Economy," by Eugene L. Grant, and published by Ronald Press. They are used with the permission of the author and publisher.)

Problem 1.—(*a*) A certain mining property has a 10-year life. It is financed by an investment of $100,000 made by the stockholders of the corporation which was organized to develop the property. Annual revenues are $35,000; annual cash expenditures for operation, maintenance and taxes are $20,000, leaving a balance of $15,000 each year for depreciation and profits. The property has no salvage value at the end of the 10th year.

Make the necessary compound interest calculations to determine the annual per cent return on invested capital received by the stockholders under each of the following methods of disposition of the $15,000 which is available each year, and list the advantages and disadvantages of each of these plans;

1. Payment of dividends out of capital.
2. Maintaining capital intact by means of a 4 per cent sinking fund.

(*b*) Contrast the situation in (*a*) with that of an industrial concern which may look forward to an indefinitely continuing life, which owns many items of equipment with different expected lives, which is expanding somewhat each year, and which does its financing partly by the issuance of common stock and partly by the use of bank loans.

In such case what objections may be raised to each of the two types of financial provision for depreciation considered in (*a*)? What alternatives are there that seem to be more desirable in this case?

Problem 2.—In developing an ore deposit, two methods of mining are available. One will recover 80 tons for every 100 tons in the deposit and will cost $2.10 for each ton recovered; the other will recover 88 tons for every 100 tons in the deposit and will cost $2.30 for each ton recovered.

(*a*) Under what conditions is this a break-even point problem, and under such conditions, what is the break-even point in value of the recovered ore below which the low recovery method should be used and above which the high recovery method should be used?

(*b*) Under what conditions is it more economical to use the low recovery method, regardless of the value of the recovered ore?

ENGLISH NOTES

DEVOTED TO THE INTERESTS OF TEACHERS
OF ENGLISH IN ENGINEERING SCHOOLS

HOMER H. NUGENT, *Editor*, Rensselaer Polytechnic Institute

The following examples are taken from papers presented at the Conference for Teachers of English in Technical Schools, at the University of Michigan, June 30–July 18, 1941.

TEACHING LITERATURE IN AN ENGINEERING SCHOOL

By JOSEPH L. VAUGHAN
University of Virginia

There are, it seems to me, three things that must be considered with regard to teaching literature in an engineering school: first, the attitude of the dean and the faculty in the engineering department; second, the type of professor of literature in the engineering department; and third, the engineering student.

No one will deny that it is imperative for a teacher of literature to have the full support of the administration and faculty in the engineering department. On one occasion, I heard a well known engineering dean pay a glowing tribute to the cultural value of courses in literature. He overdid himself in stressing the importance of such work. Later in the afternoon, however, he told some of his cronies: "I like the literature courses all right, but I won't give them much time in the curriculum, and that's what the professors of English are always yelling for, confound them." I noticed that the courses in English in his engineering school were not given much consideration by the students, for the wise undergraduate knows his own dean and quickly detects the difference between real appreciation and lip service.

Fortunately these days most of the deans and professors of technical subjects are more sympathetic and want their students to become acquainted with great literature under the guidance of stimulating teachers. The alert technical man knows the value of

literature and urges students to seek courses outside of the scientific fields. One prominent dean of engineering has stated: "The course in literature is just as important as the one in electrical engineering, for literature is a transcript of life. In fact, it *is* life."

It all sums up to this: the technical faculty undoubtedly sets the tone of the engineering school. If this group approves of the work in literature, supports it financially, and commends it to the students, they will already have much of the interest we try so earnestly to stimulate. One major professor of an engineering subject can do more to arouse interest in literature than the whole English staff.

The teacher of literature also has to do his part. At the outset he must admit that he is dealing with a non-major in English who insists upon being an engineer, not a candidate for the Ph.D. in English. Once this proposition is accepted, the professor of English can adjust himself and his course to the needs of the non-majors. If the instructor is unwilling to make this important concession, his course will surely fail.

All of us are acquainted with the type of professor who is so absorbed in graduate teaching and research that he ignores, or has scant time for, the undergraduate non-majors in English. Since he has to make a living, he tolerates them but confesses that his life would be much happier without them. They take up too much of his valuable time. This type of instructor, totally unsuited for teaching undergraduates, will solemnly declare that engineers are not interested in literature.

His engineering students will have a different story to tell. Snickering, the lusty young barbarians will say in their own elegant phraseology that he is monotonous and dry as dust; that he, to quote one group I happen to know, is "an academic sourpuss."

Both are wrong in their appraisals, and both are living in different worlds with opposed standards. The professor could save the day if he would realize that his students are *not* majors in English and do not *want* to be. (In an aside, I might add that nine-tenths of his students are in this classification, but he makes little provision for the people in pre-medical, dental, agricultural, home economics, architectural, and other groups.) And the students could help if they would try to see his point of view. But being what they are, the undergraduates will never make the effort. They aren't built that way.

There never has been a time, however, when boys (and that's all they are despite our fancy classifications) would not respond to red blooded teachers who stay in the highroad of life. Show me a successful teacher of undergraduates, and I will show you a leader

in the best sense of the word. No dry bones of graduate research for young men of eighteen or twenty; they are not ready for it and do not appreciate what it means. Good teachers know this.

FORMS OF LITERATURE

By CHARLES J. ADAMS

Worcester Polytechnic Institute

The drama, the short story, and the essay—these are the forms to which our courses in literature at the Worcester Polytechnic Institute are at present limited. The drama and the short story we selected because they are the forms which will chiefly occupy the leisure hours of our students throughout their lives. Stories they will find—and read—in almost every magazine they pick up; plays they will frequently go to see, either on the stage or on the screen. It seems to us highly desirable that they should learn to discriminate, in Matthew Arnold's apt phrase, between the excellent, the less excellent, and that which has no excellence. This power we try to give them. We also emphasize the office of these types in broadening the horizons of the intellect and the imagination, and in deepening the understanding of human nature.

On the study of the essay we base our course in freshman composition. The engineering student's lust for facts may be depended on to carry him more or less safely through the factual essays with a minimum of aid from the instructor. It is chiefly in the informal, personal essays, like those of Charles Lamb among the older writers, or of Samuel McChord Crothers among more recent ones, that his interest is inclined to lag. When it does, it can usually be revived by a discussion of the author's life and its relation to his writings; and an occasional hour spent in talking about the friendships of Lamb and Coleridge, of Coleridge and Wordsworth, expanding to take in most of the other famous writers of the period, opens the door to many a profitable excursion into fields that otherwise would remain unexplored.

One of these is the field of poetry. Although we offer no regular course in poetry, each instructor is encouraged to read to his classes as much poetry as he pleases, either to illustrate the matter in hand, or to accomplish any other desirable purpose. In this way a good many poems are presented, with, I am happy to say, some gratifying results. When, for instance, I find an entire class agreeing that the story told by William Morris in "The Haystack in the Floods" could not have been told more effectively in prose; when any one of

a hundred mid-Victorian poems can open my students' eyes to the literary implications of the Darwinian theory; when Robert Frost's "Birches" or Edwin Arlington Robinson's "Isaac and Archibald" inspires them to write essays about their own young boyhood; or when, some fine May morning, a poem by Robert Herrick or Sir John Suckling sets even the most lethargic pulses dancing—when these things happen, as they not infrequently do happen in my classes, I thank God that the magic of poetry is still potent, even in a modern engineering college classroom.

WAR-TIME PLAN FOR THE COMMITTEE ON ENGINEERING SCHOOLS OF THE ENGINEERS' COUNCIL FOR PROFESSIONAL DEVELOPMENT

Many members of engineering college faculties are carrying additional responsibilities during the war as consultants or teachers of E. S. M. D. T. courses. Some engineering departments have temporarily lost important staff personnel to military service or research. Preparation for inspection or reinspection by a delegatory committee of the Engineers' Council for Professional Development is an obligation which in many instances it is possible and safe to postpone, and members of these visiting committees often find it difficult to arrange for even short inspection trips.

For the above reasons the Committee on Engineering Schools, E. C. P. D., with the approval of the Executive Committee proposes to defer many of the inspections and reinspections of engineering curricula which would normally be conducted during this year and next. The understanding is that, pending reinspections, existing accreditations will be continued. Exceptions to the above plan will be made in cases which seem to regional chairmen to need attention or when postponement of an inspection would be unjust to a college.

NECROLOGY

BERT N. BLAKESLEE, who was 64 years old, died February 26, after a week's illness. For the past 20 years he had been head of the department of architectural engineering and one of the oldest members of the faculty in point of service. He came to the University in 1923 to establish the department of achitectural engineering. Under his direction the department gained national recognition for its high and rigid standards of scholarship.

Professor Blakeslee was a graduate of the University of Michigan. He also held a life teaching diploma from the Michigan State Normal College. At the turn of the century he taught science and mathematics in the Bay City High School for three years. After the Spanish-American war he was sent by the U. S. government to teach the natives at Banton Province (now Jones Province) in the Philippines. After teaching in the Philippines from 1901 to 1903, he returned here to accept an appointment as head of the engineering design department of the Canadian Bridge Co. in Walkerville. He was also employed by the American Bridge Co. and Field and Hinchman, consulting engineers, before coming to U. of D.

Professor Blakeslee was a member of the Engineering Society of Detroit, the Society for the Promotion of Engineering Education, the Citizens' Advisory Committee of the Detroit Civic Planning Commission. At U. of D. he served on the faculty council of the College of Engineering, as well as the board on student organizations, and the committee on student advisement and student organization.

ADAM C. DAVIS, Head of Department of Experimental Engineering at Cornell University, died March 17, 1942, after a brief illness. Professor Davis was graduated by Cornell University in 1914 and was appointed in July 1936 to the position he held at the time of his death.

MISS SADA ANNIS HARBARGER, associate professor, department of English at Ohio State University, died Thursday, April 23, in White Cross hospital, Columbus. Although in failing health for the last year, Miss Harbarger had been confined to the hospital only since February 14.

Born in Columbus where she attended high school, Miss Harbarger received her bachelor's degree from Ohio State in 1906, and

her master of arts degree from the University of Illinois in 1909. Until 1917 she was a member of the faculty of the Department of English at Illinois. During her summers she taught at Columbia University and at the New York School of Commerce and Finance. She had been a member of the faculty at Ohio State since 1919.

Miss Harbarger was the author of "English for Engineers," which has gone through four editions and is widely used; she was also co-author of "English for Students in Applied Sciences," with Wilson R. Dumble, William H. Hildreth, and Bert Emsley.

Widely respected by men in the engineering profession, Miss Harbarger had long been active in the Society for the Promotion of Engineering Education, and in the Ohio Section of that organization. She had been secretary of the Ohio Section since 1922, and she had been Vice President of the Society in 1936–37, and a member of the Council 1926–29.

EDWARD C. SCHMIDT, Professor Emeritus, University of Illinois, died March 21, 1942. Professor Schmidt had been a member of this Society since 1907.

ARTHUR NEWELL TALBOT, Professor Emeritus, University of Illinois, died April 3, 1942. Professor Talbot was a charter member of this Society, Treasurer 1902–04; Vice President in 1909–10; President in 1910–11 and a member of the council since that date. He was the fifth recipient of the Lamme Medal from this Society.

NEW MEMBERS

BEAM, ROBERT E., Assistant Professor of Electrical Engineering, Southern Methodist University, Dallas, Texas. R. M. Matson, E. M. Harrison.

BRACH, EARL T., College Dept., International Textbook Company, Scranton, Pa. Wm. Bayless, Sam. Baker.

CLARK, DONALD S., Assistant Professor of Mechanical Engineering, California Institute of Technology, Pasadena, Calif. R. W. Sorensen, Franklin Thomas.

DUNN, CLARK A., Associate Professor of Civil Engineering, Oklahoma A. & M. College, Stillwater, Okla. R. L. Flanders, E. R. Stapley.

JONES, EDWARD N., Dean of College, Baylor University, Waco, Texas (after June 1942, President Texas College of Arts & Industries, Kingsville, Texas). H. W. Straley, Sophus Thompson.

JONES, MERTON W., Instructor in Physics, Clarkson College of Technology, Potsdam, N. Y. Fred F. Piper, W. H. Allison.

MURDICHIAN, KARMY K., Instructor in Civil Engineering, Virginia Polytechnic Institute, Blacksburg, Va. D. S. Trowbridge, E. B. Norris.

OTHMER, MURRAY E., Assistant Professor of Chemical Engineering, Tufts College, Medford, Mass. H. P. Burden, F. N. Weaver.

STOEVER, HERMAN J., Associate Professor of Mechanical Engineering, Iowa State College, Ames, Iowa. L. O. Stewart, D. L. Arm.

TAYLOR, WILLIAM H., Professor of Drawing and Surveying (Supervisor E. S. M. D. T. Program), University of Alabama, University, Ala. S. C. Houser, L. P. Arduser.

178 new members this year.

INDUSTRIAL ENGINEERING DIVISION

Below is a list of nominations for members of the executive committee of the Division of Industrial Engineering who will be voted on Saturday, June 27, 1942. Our constitution states that, "Nominations shall be made by this (nominating) committee sufficiently early in the year to allow printing in the JOURNAL previous to the annual meeting." I shall appreciate, therefore, if you can make arrangements to print this list of nominees in the next issue of the JOURNAL.

G. W. Barnwell.....Stevens
D. B. Porter.....N. Y. U.
C. W. Beese.....Purdue
C. L. Eddy.....Case
P. N. Lehocsky.....Ohio State
C. A. Koepke.....Minnesota

Very truly yours,
H. G. THUESEN

SECTIONS AND BRANCHES

At the annual election meeting of the **Lafayette Branch** of the Society for the Promotion of Engineering Education, held April 30th, the following officers were elected for the 1942–43 year:

Chairman—W. G. McLean.
Vice-chairman—G. F. Roehrig.
Sec'y-Treas.—E. L. McMillen.

During the past year at Lafayette we have held meetings on such interesting subjects as "The Evaluation of the Lafayette College E. S. M. D. T. Program," "The 1942 Boys' Engineering Guidance Conference at Lafayette College," and "Mass Production of Airplanes." The first two subjects were covered by members of the College Faculty who are participating in the enterprises. We were most fortunate in obtaining Mr. Wm. T. Piper of the Piper Aircraft Company to deliver the very interesting talk on the problems facing the airplane industry today. We feel that we have had a successful year despite the pressure under which engineering faculties are working in this emergency.

WM. G. MCLEAN, *Secretary.*

On Saturday, April 18, the University of Akron was host to the Spring meeting of the **Ohio Section** of the Society for the Promotion of Engineering Education. Held at the University Club, the meeting was in charge of Fred S. Griffin, University of Akron. The afternoon meeting was in charge of M. S. Douglas of Case School of Applied Science.

Following an address of welcome by H. E. Simmons, president, University of Akron, the morning program consisted of addresses by W. S. Dowman, of the Goodyear Aircraft Corp., and by Willard E. Nudd, registrar at Case School of Applied Science. At the afternoon session addresses were made by the following speakers: Paul E. Belcher, chairman of Akron Draft Board No. 13; by C. Arnold Hanson, director of Defense Training at the University of Akron; and by William E. Umbach, Department of English at Case School of Applied Science. Interesting discussions followed each talk.

Officers elected for the Spring 1943 meeting which will be held at Ohio State University were as follows:

Chairman: J. R. Shank, Ohio State University; Vice Chairman: M. E. Haas, University of Dayton; Second Vice Chairman: E. O. Scott, University of Toledo; Secretary: Sada A. Harbarger, Ohio State University; Assistant Secretary: Wilson R. Dumble, Ohio State University.

COLLEGE NOTES

Announcement has just been made of the Summer Management Course offered by the **University of Iowa** from June 8 to June 26. This course, now in its fourth year, is held especially for people in industry interested in comprehensive training in production planning—routing and scheduling of work, motion and time study, layout of manufacturing equipment, waste elimination and related subjects. Also, people planning to teach National Defense Training courses in production management, production supervision, motion and time study, or plant layout will find this course of value.

Inasmuch as the development of better methods represents one of the most effective ways of increasing production, the course stresses those fundamental principles and techniques which can be used to bring about improvement of production methods.

The purposes of the course are:

1. To show how production can be coördinated with the various activities of an organization.
2. To present the fundamentals of motion and time study.
3. To afford an opportunity for applying the above principles to individual problems in the laboratory.
4. To show how training programs in this field can be carried on in factories and offices.
5. To provide an opportunity for discussing the problems common to production planning and motion and time study work in various fields.

The course is open to plant and office managers, industrial engineers, superintendents and foremen, college and university instructors, and all those interested in improving methods in their plants and offices. In the past the men attending have included a great diversity of businesses—banks, mail order houses, U. S. Government agencies, drug supply houses have been represented, although the majority of the members come from manufacturing industries.

The enrollment is necessarily limited, as about half of each day is spent in working out practical problems brought by the members themselves from their own plants. This work involves use of laboratory equipment, that is, tools, work benches, projection equipment for film analysis, all of which are provided by the University in amounts adequate for those admitted to the course.

The course is under the direction of Ralph M. Barnes, Professor of Industrial Engineering at the University. He is assisted by a staff of capable men from the University and from industry.

The course is high-lighted by a number of special lecturers who visit the campus during the course. Among this summer's visiting lecturers will be:

		Subject
John A. Aldridge.	Exec. Operating Staff, Sears, Roebuck & Co., Chicago, Ill.	Motion Study in the Field of Distribution.
W. E. Crotsley.	Production Manager, International Business Machines Corp., Endicott, New York.	Methods of Production Control.
Harold Engstrom.	Supervisor of Standards, Bendix Radio, Baltimore, Maryland.	(*a*) Motion Study Training Programs for Supervisors and Foremen. (*b*) Development and Use of Standard Data for Setting Time Standards.
Lillian M. Gilbreth.	President, Gilbreth, Inc., Bloomfield, New Jersey.	Motion Study Today.
Robert I. Hale.	Industrial Engineer, Glenn L. Martin Co., Baltimore, Maryland.	Standard Practice Instructions.
W. F. Heising.	Supt. of Manufacturing, W. A. Sheaffer Pen Co., Ft. Madison, Iowa.	Stabilization of Employment.
J. K. Louden.	Director of Industrial Engineering, National Supply Co., Pittsburgh, Pa.	The Place of a Wage Incentive System in an Industrial Engineering Program.

A fraternity house will be taken over by those who wish such living quarters. A public speaking course is offered to those who attend, a daily luncheon club features speakers both from within the course and from outside, and often evening discussion groups gather voluntarily to continue the day's discussion and to compare ideas brought from their own experiences.

SECOND HYDRAULICS CONFERENCE, IOWA INSTITUTE, JUNE 1–4

Arrangements for a Second Hydraulics Conference, to be held at Iowa City June 1–4, are now being completed by the Institute of Hydraulic Research of the University of Iowa. In view of the tremendous role played by the science of fluid motion in the present emergency, the conference will place emphasis upon those phases of hydraulic engineering which involve fundamental principles of mutual importance to other engineering professions and defense agencies of the Government. In order that such interchange of knowledge may be of widespread benefit, papers are to be presented not only by outstanding hydraulic engineers, but also by prominent representatives of related scientific fields. The Society for the Promotion of Engineering Education and the American Societies of Civil and Mechanical Engineers are jointly sponsoring the Conference.

The opening session is to be devoted to two general addresses on the application of present-day knowledge of fluid motion to both hydraulic engineering and modern warfare. Aside from an afternoon demonstration of the facilities and research projects of the Institute Laboratory, the six remaining sessions of the four-day conference will be devoted to papers showing the inherent relationship of such pertinent fields as marine engineering, meteorology, conservation, and aviation to various aspects of applied fluid mechanics.

The proposed program, together with the speakers who have already accepted invitations to present papers, is as follows:

MONDAY, JUNE 1

9:00 A.M. *Scope and Importance of Fluid Mechanics.*

The Significance of Fluid Mechanics to the Hydraulic Engineer, Boris A. Bakhmeteff, Columbia University.

The Role of Fluid Mechanics in Modern Warfare, Theodore von Kármán, California Institute of Technology.

1:30 P.M. *Modern Methods of Research.*

Latest Developments in Hydraulic Laboratory Technique, Joseph B. Tiffany, U. S. Waterways Experiment Station.

Principles of Towing Tank Research, L. A. Baier, University of Michigan.
General Aspects of Wind Tunnel Investigation, A. M. Kuethe, University of Michigan.
Measurement of Sediment Transportation, E. W. Lane, University of Iowa.

TUESDAY, JUNE 2

9:00 A.M. *Mechanics of Fluid Resistance.*

Hydraulic Aspects of Form Drag, Max M. Munk, Catholic University.
Evaluation of Boundary Roughness, Hunter Rouse, University of Iowa.
Resistance of Non-homogeneous Fluids,
Fluid Flow through Porous Media, Morris Muskat, Gulf Research and Development Company.

1:30 P.M. *Inspection of Hydraulics Laboratory.*

All equipment in the Institute Laboratory will be in operation, and current research projects will be demonstrated by members of the staff.

WEDNESDAY, JUNE 3

9:00 A.M. *Cavitation Phenomena.*

Cavitation Problems and their Effect upon the Design of Hydraulic Turbines, J. M. Mousson, Rustless Iron and Steel Corporation.
Cavitation Problems in Pumps, George F. Wislicenus, Worthington Pump and Machinery Co.
Studies of Cavitation in Hydraulic Structures, Harold A. Thomas, Carnegie Institute of Technology, and William J. Hopkins, U. S. Engineer Corps.

1:30 P.M. *Problems of Wave Motion.*

Beach Wave Investigations, Martin A. Mason, Beach Erosion Board.
Flood Wave Characteristics, Chesley J. Posey, University of Iowa.
Wave Motions in the Atmosphere and Application to Forecasting, Harry Wexler, U. S. Weather Bureau.
Gas Wave Analogies in Open Channel Flow, Arthur T. Ippen, Lehigh University.

THURSDAY, JUNE 4

9:00 A.M. *Engineering Aspects of Fluid Turbulence.*

Turbulence in the Atmosphere, C. G. Rossby, University of Chicago.
The Role of Turbulence in River Hydraulics, A. A. Kalinske, University of Iowa.
Evaporation Studies, C. W. Thornthwaite, Soil Conservation Service.
Mixing Characteristics of Density Currents, Robert T. Knapp, California Institute of Technology.

1:30 P.M. *Sediment Transportation.*

The Effect of Turbulence in Retarding Settling, Thomas R. Camp, Massachusetts Institute of Technology.
Fundamental Aspects of Sediment Characteristics, W. C. Krumbein, University of Chicago.
Bed Load Transportation in Rivers, H. A. Einstein, Soil Conservation Service.
Wind Influences on the Transportation of Sand, Helmut Landsberg, University of Chicago.

There are indications that the second conference will attract as notable a gathering of engineers as did the first of this conference series in 1939. Dormitory and hotel accommodations will again be arranged for those attending the sessions, and in addition one of the large fraternity houses on the University campus will be open exclusively to conference guests. Reservations may be made in advance by writing to Professor J. W. Howe, Engineering Building, University of Iowa, Iowa City.

BOOK REVIEWS

Technical Report Writing. FRED H. RHODES. McGraw-Hill Book Company, 1941. First Edition, 125 pages. Price $1.50.

This attractive new book is primarily addressed to the chemical engineer, though it is of direct value to the scientific observer in other fields. It emphasizes the scientific attitude toward making, recording, and preparing statistical data, having in mind their ultimate use in technical reports. There are many excellent pieces of advice and precautionary statements running all through the book. It is written well, by an experienced researcher.

Perhaps more recognition might have been given to the purpose of the proposed report. A wider field of application might be perceived than the author seems to have in mind as he writes.

The book would be strengthened if more direct applications were cited of its rather concentrated chapters on graphical illustrations, and methods and results of statistical studies of data. The latter, especially, needs more interpretation in its influence upon the writing of the report.

O. J. FERGUSON

The Development of Mineral Industry Education in the United States. THOMAS T. READ, Professor of Mining Engineering, Columbia University. Published by A. I. M. E., Seeley W. Mudd Fund, 289 pages.

T. T. Read, in his book entitled "The Development of Mineral Industry Education in the United States," has told the mineral industry educators things about our professional lives we never knew before, and we long have needed it. I commend to your attention the Tom Read style; whether in an *Atlantic Monthly* or in the present book; the words and ideas flow regularly and smoothly, like a spigot discharge of a well regulated mill classifier. The publication of the book and its distribution has been made possible through funds furnished by the Seeley W. Mudd Fund.

In Chapter II "American Beginnings," in Chapter III, and in Chapter IV, "Unsuccessful Ventures," the author has traced and brought to light several interesting, but forgotten "Lost Colonies of Roanoke" in our own professional field. In addition, our profession is so new and has developed so fast that the author was able to verify much material through men now alive and active. If this

had not shortly been recorded, vital battles in our war for recognition would have been unknown.

To those of you who are not familiar with the "Rise of the State Schools" Chapter VII, and elsewhere, I ask you to read with care and under the surface. Whether you like it or not, the State supported mineral industry schools, under varied names, are rapidly submerging the privately endowed schools, whether in the east or elsewhere. The buildings and equipment, research facilities and field services of these State supported schools are so great that, under wise leadership, they shortly should not only dominate mineral industry education, but ought to lead it to higher professional standing. You can't read the book honestly and escape this conclusion.

The book should also be considered from the viewpoint of its effect on the non-engineering educational world. After I read the book for the first time, I told Dr. Read that he had made mining engineering respectable. I remember that not twenty years ago, a friend showed me a clipping from a news note from Oxford University to the effect that the profession of engineering was becoming "almost respectable." I say in all seriousness that a host of our university colleagues in the Liberal Arts and Humanities hold this point still. To them I commend nameless paragraphs in the book which reveal the indifference and open hostility with which mining education was first received by the faculties of some of our universities and liberal arts colleges. In some cases we were starved out and forced to start our own schools. This conflict has by no means ended. There still seems a gulf between those educators whose world is "words and ideas" and those whose world is "facts and applications." To the non-engineering educator the book gives a right to academic and professional respectability. Especially would I commend to this group that they will find in the development of our many schools, no "smorgasbord" of palatable subjects, no degree in two years, no dusting off of outmoded medieval theories. Always every school has advanced toward a high and more rigid curriculum through willingness at trial and error, and emerging with a common objective and standard that is being justified by our product. Read behind every school description and you must get this lesson.

And, finally, how about our engineering colleagues? I anticipate that many of them will pick up the book, look for formulæ, or flow sheets, or flotation theory, and not finding any, throw down the book as useless. Some day the mineral industry engineers will find out that we do not live by bread alone; that there is something more to life than technical formulæ; that they are part and parcel of a

great developing profession, and whether they like it or not, they cannot escape from the past development of the profession or their present professional relations to others of the same stripe.

Dr. Read's book rightly interpreted will tell you what process has moulded you and "Why we behave like Mining Engineers." It will tell you why you did not get this or that study in your four year course which you later felt you should have had. It reveals to you that you are a member of a very old craft, and a very new profession, still going through its birth pains. Fifty years is a short time, and yet look what we were in an educational way fifty years ago. See that when we educated you we were experimenting with curricula and you were an ignorant guinea pig. Personally, I hope this experiment will always go on; with it we grow, without it, we become as dead as the ancient languages.

Note most of all from the book that mineral industry education must furnish you a background for your whole life not only technically, but professionally. Your curricula has, in the past, developed you technically. It is up to the present and future to give the curricula *professional* emphasis.

Please read, and chew, and swallow, and digest the book, and then see if you don't come out with the feeling that the next step in American mineral industry education is brought out of page 286 that—"Character, human sympathy, vision, clear thinking and force are, after all, the alphabet that spells success for an engineer and for a citizen, and affords that person satisfaction which is the chief goal of existence." This is not technical material but an intangible professional goal with which we all join Dr. Read in saying AMEN! AMEN! and AMEN!

Dr. Read, in making us think this way, you have done a better job than you knew!

E. A. HOLBROOK

Engineering Electricity. RALPH G. HUDSON. Third Edition, 1941. John Wiley and Sons, Inc., New York. $3.00.

This text is intended for engineering students not majoring in electrical engineering but may also be employed as an introductory text for electrical engineering students. The edition, with only 279 pages, retains the same condensed, light weight form of previous editions. The text is well illustrated and evidently many of the illustrations in this edition are new.

There are 16 chapters. Wire tables, resistivities and dielectric constants, magnetization curves, and 218 practice problems supplied with answers, are given at the end of the text.

B. K. HOVEY

Standard Handbook for Electrical Engineers. ARCHER E. KNOWLTON (Editor-in-Chief). McGraw-Hill Book Co. Seventh Edition, 1941, 2303 pages, 1700 illustrations, 600 tables. $8.00.

From the preface, the reader may find that, "before planning the seventh edition, the editors interviewed over 100 electrical engineers in well-diversified professional activities to ascertain what they expect of an engineering handbook. Thus these current users of this handbook collectively set the pattern for this complete revision. One fact which stood out above all others was that the demand is for an orderly compilation of the working-tool information of electrical technology which has been authenticated by research and experience but is not generally accessible in compact form."

The format for the 7th edition is new. It has been set in a standard textbook-size page for the first time.

More than one hundred engineers and scientists (many new ones) have contributed authoritative information which includes the most up-to-date material. Considerable new material has been added to many topics, to mention a few, air-conditioning, high voltage, generators, power transmission, electronics, telephony, and many others. Practically all subjects included in the book have been expanded, rewritten and brought up-to-date.

The index has been expanded along topical lines, with increased cross-referencing.

Plenty of usable data from all fields of electrical engineering, plus fundamental theories and standard dependable formulæ, are conveniently located, near tables of factors, throughout this volume. Descriptive material is clear and concise. The profuse use of diagrams and illustrations, wherever they contribute to pertinence and applicability, improves the comprehensiveness of many explanations of theories and fundamental principles.

The volume as a whole is such a comprehensive treatment of the field of electrical engineering that one cannot do justice to it in a brief book review. All electrical engineers will want this handbook to be easily accessible and they will appreciate it more and more as they use it from day to day.

R. C. GORHAM

Fundamentals of Industrial Psychology. ALBERT H. WALTON, Ph.D., Associate Professor of Psychology in Extension, The Pennsylvania State College. McGraw-Hill Book Co., 222 pages. $2.00.

This readable, interesting and suggestive course in Industrial Psychology was written, used by and rewritten for the benefit of those in supervisory positions in industry, especially for foreman

discussion groups. It is therefore different in its treatment from the usual text for undergraduates in psychology. It is direct, selective and practical in its treatment.

Psychology and Its Methods emphasizes the experimental, statistical method. It brushes aside phrenology, hunches and superficial methods of selection of men for jobs.

The chapter entitled Human Habits describes how we "get that way," the part which emotions, action and reason play. There is something here for the foreman to think about in trying to influence others, and in measuring his own effectiveness.

Aptitudes and Abilities, Tests: Their Construction and Evaluation and Tests: Varieties and Industrial Uses are all sound, clear chapters which are treated with due caution and common sense.

The Basis of Personality rationalizes Freudianism and other isms, keeps fundamental principles before the mind. Everyone should read this chapter and brush bug-a-boos out of their heads.

Resistance to Change lays the ground work for a discussion of Management and Psychological Factors Enhancing Productivity. The old Efficiency Engineering is criticized and the basis laid for intelligent human relations.

Principles of Learning and Training leads up to When the Human Machine Gets out of Adjustment and they place definite responsibilities on the Supervisor with numerous helpful suggestions.

Monotony, though "of considerable importance, is probably much overstressed." "Monotony does not reside in the job. It is in the worker."

Chapter XIV, Motives, Labor Unrest and Morale; XV, Attitude Building and XVI on Self Improvement constitute a triology of information and discussion of motives, escapes, ill will, leadership, self-improvement, the past and the future.

Designed for foreman discussion, directed at traditions and practices that need to be questioned and well filled with good sense, it should be required reading for labor leaders, managers and politicians.

R. L. SACKETT

Sales Engineering. BERNARD LESTER. John Wiley and Sons, Inc., 1940.

Sales Engineering succeeds admirably in reaching the primary objectives stated by the author, ". . . to place before the younger sales engineer in simple terms, without sales promotion adornment, the principles of sales engineering, to indicate to him the importance of his burden, and to suggest the opportunities for him in

present day society." The book describes the field of sales engineering, discusses the work of the sales engineer in selling, and gives many useful suggestions regarding the development of the sales engineer. The style is readable and numerous case examples lend vitality to the discussion.

The clear treatment of fundamentals to be stressed in a sales training program should be helpful to those responsible for sales training work and particularly to young sales engineers in process of training. The book is not designed, however, to serve as a text for a course in salesmanship, nor could it be used directly as the major part of a sales training program in an individual company. To an experienced sales engineer the book would be interesting because of its well-organized description of selling practices and review of fundamentals.

Another and extremely valuable use is in portraying the field of sales engineering to young engineers during their college training. Altogether too many engineers consider that selling, even of technical products, is something akin to selling brushes door-to-door and will have none of it. As a result, many technical schools and colleges under normal conditions are not able to supply requests for potential sales engineers despite the fact that many of their graduates have the necessary personal aptitudes for success in selling. It is to be hoped that as many engineering students as possible have an opportunity to read Mr. Lester's book.

Ross M. CUNNINGHAM, M. I. T.

Metal Processing. ORLAN WILLIAM BOSTON, Professor of Metal Processing and Chairman, Department of Metal Processing, University of Michigan. Published by John Wiley and Sons, Inc., New York, 1941. xiv plus 630 pages, approximately 6" × 9", profusely illustrated. Price $5.00.

This volume is a revision of Professor Boston's two volumes on "Engineering Shop Practice," published in 1933 and 1935, consolidated with more recent data. It was written on the background of his twenty years of experience in teaching the subject of machine shop practice to upperclassmen of mechanical and aeronautical engineering at the University of Michigan; and is essentially a college textbook, but is very suitable also for short defense training and industrial courses, or for self instruction, and as a reference book for detail of practice.

The text is excellent; and for the most part the illustrations are good, both the diagrams and the half tones, though some of the latter might well be supplemented by a line diagram to clarify the particular feature the illustration was used for. A valuable feature of

Engineering Shop Practice was a short list of questions printed at the end of most of the chapters, and these question lists with only very minor changes or omissions have been reproduced in this revised edition. This is an interesting point as it indicates that the present volume has succeeded in including most of the more important subject material of the earlier more voluminous volumes, in shorter though still adequate form. A short bibliography also is inserted after most of the chapters.

Professor Boston has defined his book title; "Metal processing deals with machine tools, small tools, accessories, and processes by which the production of parts or devices is accomplished in single units, small quantities, or mass production." It seems to the writer that some such title as Machine Shop Principles and Practice would indicate better to the average person the subjects covered in the above definition and in the text. The text includes a great deal of description of the features of the different machines that are of most importance, rather than so much general descriptions of things likely to be changed radically and frequently. Machinability also is particularly emphasized and the surface finish resulting from various factors. Many practical recommendations are included on details of machine work.

Chapter I, An Introduction to the Study of Machines, Tools, and Processes, covers—quoting from the preface—"All steps involved in designing for production.—The manufacturing drawing with tolerances and surface quality indicated, the analysis and form of material used, the machining operations desired, the machine tools, the cutting tools, and accessories needed for manufacture and inspection lead naturally to the final plant layout."

"Subsequent chapters treat in detail the various classes of machines, processes, and factors involved so that the student develops the ability to plan from its drawing the production of a part for various conditions of quantity and quality."

S. L. GOODALE

Structural Drafting. C. T. BISHOP. John Wiley and Sons. 287 pages. Price $3.50.

This book is a development from a previous book by the same author that has had considerable success. The book is written on the theory that the draftsman must be familiar with shop procedure before he can attempt to make drawings for use in a shop. The first three chapters cover shop methods of steel manufacture and fabrication to familiarize the draftsman with the properties, uses, and purposes of structural steel. The remainder of the book covers the general features of drafting; first, as a general technique and second,

as in its relation to structural work. Included in this section are discussions of conventional methods of drawing and of billing. The arrangement of the drawing in a logical and systematical method is stressed.

The chapters on the drawing of actual structural problems are very complete in subject matter; and the usefulness is increased by the inclusion of a large number of typical drawings. These typical drawings are made in great detail and are of much value in explaining the applications of the material covered in the early part of the book.

If a student were to familiarize himself with the information in this book, he should have no trouble in holding a position in a structural drafting room.

FRANK BROMILOW

Design of Modern Steel Structures. L. E. GRINTER. The MacMillan Co. Price $5.00.

The arrangement of the material in this text is the most practical that has appeared for a book of this type. The design of connectors being first allows the instructor to cover that material thoroughly and at the same time review the material that has been covered in the courses in Strength of Materials and Structural Analysis.

The actual design of complete structures is left until the second half of the book. This allows the student to apply those principles that he has learned in the first half of the book. The use of standard A. I. S. C. members and connections and the reference to the use of the A. I. S. C. handbook give the student practice in the use of this handbook.

The use of welding is covered very thoroughly, but with no slighting of the design of riveted joints. The design of the beam and girder type of construction used in modern office building is emphasized in the book, and a complete tall building design is included. Plate girders, truss bridges, and roof trusses are covered as is common to most structural design books.

The principal value of this book lies in its arrangement and in the inclusion of numerous illustrative problems complete with solutions. This makes it possible to make assignments that can readily be understood and the problems assigned can be worked at home by the students.

As is usual in a first edition, there are a few mistakes in the problems. Some of these are typographical, and a few are due to the possibility of the student misunderstanding the purpose of the author.

FRANK BROMILOW

Soil Mechanics. DIMITRI P. KRYNINE. McGraw-Hill Book Co. 437 pages.

This book is the first really successful effort to present the principles of soil mechanics in a simple enough form so it may be used as a text book for undergraduate students. The division of the book into the three parts (1) Elements of Soil Physics, (2) Elements of the Mechanics of Earth Masses and (3) Structural Application seems to the reviewer to be a logical arrangement of the subject matter. The section on structural application is particularly valuable since it includes not only applications of the soil principles, but also includes many discussions of actual problems and their solutions.

The inclusion of problems at the end of the elementary chapters and the addition of references at the end of all chapters does much to increase the usefulness of the book. The addition of answers for some of these problems would further strengthen the book.

The sections that require higher mathematics, such as the theory of consolidation, are written in such a manner that they may be omitted without impairing the value of the other material. This is very important in the case of undergraduate students who may not have had the higher mathematics.

FRANK BROMILOW

Elementary Structural Engineering. L. C. URQUHART AND C. E. O'ROURKE. McGraw-Hill Book Co. 348 pages.

This book covers a wide range of subject matter in a brief and elementary manner. The book is to provide a text book for non-civil engineers and also to provide a guide for the practicing engineer. Much of the material at the beginning of the book reviews information that is covered in a formal course in strength of materials; but the material is arranged in an order that is logical for the use in structural engineering work. This introductory section contains several chapters on Structural Mechanics, Structural Materials, Loads on Structures, Homogeneous Beams and Stresses in Trusses. The remainder of the book does cover structural engineering problems.

The use of many figures and drawings helps to make the book more readable as does the inclusion of a number of example problems that are solved in great detail. The usefulness of the book as a text is limited somewhat by the lack of problems for solution by the student. The inclusion of pictures of actual structures would also contribute to the usefulness of the book.

FRANK BROMILOW

Theory of Simple Structures—Second Edition. T. C. SHEDD AND J. VAWTER. John Wiley and Sons, New York, 1941. 505 pages, 278 figures, 4 plates, cloth.

The authors have added to the first edition a section covering the basic principles involved in the analysis of indeterminate structures. This has been done recognizing the recent growth of importance of this branch of structural engineering. In so doing, they are able to give a more complete treatment of present methods of structural analysis and eliminate the necessity of an additional text for an advanced course on this subject.

In adding the new material, the book has been divided into two parts. Part I includes all the material of the first edition with a few minor revisions, and deals entirely with structures that can be analyzed by the laws of statics. Part II presents the fundamentals used in the analysis of statically indeterminate beams, frames and trusses. As in the first part, the new material is presented with a pleasing thoroughness and simplicity. All basic concepts are developed systematically and then illustrated with examples. The new section is complete with figures, plates and homework problems.

Two features of the new material have particular merit. The first is the geometric approach to the method of analysis. The authors feel this is the simplest and most fundamental attack and develop this in considerable detail. The relation of small angular changes to deformations in structures is investigated and makes possible a direct solution without the use of calculus. This is done in preference to outlining a number of sketchy solutions, which might result in a "formula memorizing" method of learning. The second feature is the portion on moment distribution. The clear, orderly presentation of this material is an evidence of the authors' association with Professor Hardy Cross.

A. C. ACKENHEIL

Notes and Problems in Blue Print Reading of Machine Drawings. D. E. HOBART, Associate Professor of Mechanism and Engineering Drawing, University of Michigan. Published by Harper and Brothers. 105 pages. Price $1.00.

The author's idea is to present a means of understanding orthographic projections to the large number of persons who now must interpret this type of machine drawing. The text includes descriptive matter, drawings and questions to be answered directly on the drawings for some fifty problems. The descriptive matter explains

orthographic projection, auxiliary views, sectioning, standard symbols, and pictorial sketching. The drawings constitute problems, a great many of which are devoted to dimensioning.

W. IRWIN SHORT

Industrial Instruments for Measurement and Control. THOMAS J. RHODES. McGraw-Hill Book Co., 1941. 573 pages, 282 figures. $3.00.

This book is one of the well known "Chemical Engineering Series." As stated in the preface, "This book is intended for use as a textbook for the formal study of the subject of instruments and automatic control in engineering schools and as a practical reference book for those concerned with instrument and control problems in industry. . . . The study of instrumentation forms a logical part of the chemical engineering course, since a knowledge of the control of chemical engineering processes and operations is usually as vital to successful plant operation as the ability to design and construct the plant. For these reasons it would seem that a comprehensive textbook on instruments should be of considerable value." The scope of the book is broad, from fundamental standards to automatic control mechanism for complicated processes. The descriptions of the various instruments are clear and complete, and the various illustrations give great clarity to the work. This book should fulfill its purposes very well as the material is vital to the chemical engineer or in fact, to any engineer, chemist, or physicist working with measuring or controlling instruments.

F. L. BISHOP, JR.

Testing and Inspection of Engineering Materials. HARMER E. DAVIS, GEORGE EARL TROXEL, AND CLEMENT T. WISKOCIL, University of California. Preliminary Edition for Engineering Defense Training Courses, lithoprinted by Edwards Brothers, Ann Arbor, Michigan, and published by McGraw-Hill Book Company, New York, 1941. xv plus 372 pages, approximately $6\frac{3}{4}'' \times 10''$, illustrated with about 140 line diagrams and figures and a few halftones. Price $3.50.

The text is divided into Part I, Principles of Testing and Inspection, which contains 183 numbered articles, grouped into eleven chapters, and occupies 257 pages. Part II, Instructions for Laboratory Work, 39 pages, presents general and detailed instructions to cover 21 problems proposed. Appendix A includes a 49 page Summary of Properties of Common Engineering Materials. Appendix B is a bibliography containing 1017 selected references. No index.

Part II. This consists of a few pages of General Instructions, then three problems on the laboratory equipment itself, and eighteen actual testing problems. These involve tension, compression, flexure, shear, hardness, impact, etc. The instructions for each test in general include objects of the testing, preparatory reading needed to be done by all persons engaged in the test, specimens and special apparatus, procedure, report and discussion, the latter being largely questions to assure proper attention to the more important details of the work.

This is an excellent text on the subject of testing and of inspection of engineering materials. It is direct and to the point in its presentation, well worded, and the type is clear. About the only criticism is the lack of an index, but that is understandable.

S. L. GOODALE

Basic Units in Mechanical Drawing—Volume I, Second Edition. RANDOLPH PHILIP HOELSCHER AND ARTHUR BEVERLEY MAYS. John Wiley and Sons, Inc. 305 pages. Price $1.60.

The authors hold, in the second edition, to the original organization of the book into small learning units. These small learning units are each divided into five divisions—(1) Purpose, (2) What you should know, (3) How to do, (4) Questions, and (5) Problems. The book is divided into two parts of seventeen units each. It is the author's belief that an abundance of teaching content for one semester's work is provided in each part, to which, after review, one will concur.

W. IRWIN SHORT

MORE ENGINEERS NEEDED

By ALFRED H. WHITE, President

The importance of trained engineers in the war effort has been stressed in the regulations of the Selective Service Act and shown by liberal appropriations for the courses in Engineering, Science, and Management Defense Training. The engineering schools have coöperated whole-heartedly by giving many specialized short courses and by accelerating their regular programs. Our Society has been urged to join in an effort to increase the number of students planning to become engineers, but has been unwilling to take any action until some high official in the War Department certified that further expansion was necessary. Such a certificate was contained in a letter from General Frank J. McSherry which is quoted in full below.

War Production Board
Washington, D. C.
April 11, 1942

Doctor John W. Studebaker
U. S. Commissioner of Education
Washington, D. C.

Dear Doctor Studebaker:

To utilize completely wartime manpower, there is a need for a very large number of additional engineers during the current year, and an annual supply thereafter for the duration of the war greatly in excess of the present supply.

There is urgent reason, therefore, to employ two measures: (1) To secure the services of all fully or partially trained engineers in the fields in which they were trained; (2) to supply engineering colleges with freshmen for their regular or accelerated beginning classes who are competent to undergo the training, and who will persist until the training is completed.

Institutions, whether of college or secondary rank, and individuals, whether youth or adults, coöperating to the above ends, are in fact rendering essential war services. I urge that both institutions and individuals take such immediate steps as are practicable to solve this pressing problem.

Sincerely yours,

(S) Frank J. McSherry
(Brigadier-General, U. S. A.)
Deputy Director for Labor Supply
and Training

This letter stressing the essential war services rendered by engineering teachers and students will, it is hoped, be effective with selective service boards, and will reassure those teachers who have felt that they were perhaps not doing their full part in the war effort if they continued their teaching work.

Commissioner J. W. Studebaker of the Office of Education has been keenly alive to this demand for engineers and has been a sympathetic administrator of the E. S. M. D. T. programs and an active supporter of requests from the engineering colleges for funds to finance the accelerated programs. The part which the secondary schools might play in supplying more engineering students was developed by Harry A. Jager, Chief of the Occupational Information and Guidance Service of the Office of Education. Your Executive Committee agreed to endorse an appeal to secondary schools to classify their seniors on the basis of preparation and aptitude, and to urge those in the selected group to undertake engineering training. Such an appeal was included in the early pages of a booklet "Engineers Are Needed," issued by the Office of Education late in April. It contained the letter from General McSherry quoted above and an introductory letter from Commissioner Studebaker from which the following paragraphs are quoted:

> The secondary schools of the country must present to engineering schools this spring a larger group of engineering students properly selected and adequately prepared.
>
> In wartime schools must do what has not always been done effectively in the past: Send to engineering schools youth so well equipped that subsequent dropouts are not caused by lack of ability or preparation (a major factor in the disappearance of two-thirds of the freshmen in engineering schools before graduation in the average engineering school during recent years).
>
> You will find enclosed a plan for increasing the supply of engineers during wartime which has the endorsement of the Society for the Promotion of Engineering Education. The engineering schools are undertaking their full share of the burden, coöperating with the secondary schools in admission procedures and using added care in preventing avoidable dropouts of students they admit.

Over 37,000 copies of this booklet were mailed to deans of engineering colleges, arts colleges and junior colleges, and to superintendents of schools and principals of high schools. It is too early yet to gage the effect of this letter, but our thanks are due to Commissioner Studebaker and his staff for the forceful presentation which they have made. We hope that a larger number of well-prepared students will present themselves to our engineering colleges so that the war effort may be speeded more fully and effectively.

FIFTIETH ANNUAL MEETING SOCIETY FOR THE PROMOTION OF ENGINEERING EDUCATION, NEW YORK CITY, JUNE 27–29, 1942

CONDENSED PROGRAM

Saturday June 27	7:00 – 9:00 A.M.	Breakfast Meeting Council, Chairmen and Secretaries of Conferences	Men's Faculty Club
	8:00 A.M.– 6:00 P.M.	Registration	Rotunda, Low Memorial Library
	9:00 A.M.–12:00 N.	First General Session	McMillin Theatre
	12:30 P.M.– 2:00 P.M.	Conference Group Luncheons	See Group Meals Schedule
	2:00 – 5:00 P.M.	Conference and Sectional Meetings	See Complete Program
	7:00 –10:00 P.M.	Conference Group Dinner Meetings	See Group Meals Schedule and Complete Program
Sunday June 28	7:00 – 9:00 A.M.	Council Breakfast Meeting	Men's Faculty Club
	9:00 A.M.–12:00 N.	Registration	Rotunda, Low Memorial Library
	9:00 A.M.	Special Chapel Service	Columbia University Chapel
	10:00 A.M.– 1:00 P.M.	Second General Session	McMillin Theatre
	2:30 – 5:30 P.M.	Third General Session	McMillin Theatre
	7:00 –10:00 P.M.	Annual Society Dinner	John Jay Dining Hall
Monday June 29	7:00 – 9:00 A.M.	Council Breakfast Meeting	Men's Faculty Club
	9:00 – 9:30 A.M.	Departure for Divisional Meetings	In front of Low Memorial Library
	10:00 A.M.–12:00 N.	Conference and Sectional Meetings	Host Institutions
	12:30 P.M.	Conference Luncheons	Host Institutions

PROGRAM OF A WAR-TIME MEETING

GENERAL INFORMATION ON THE SOCIETY'S FIFTIETH ANNUAL MEETING, NEW YORK, JUNE 27–29, 1942

BY CARL F. KAYAN *

In order that the Society's membership may have a quick preview of the events scheduled for the 50th Annual Meeting, to be held in New York on June 27–29, and may see what an excellent program in relation to the nation's war effort has been arranged

Entrance to Columbia University at Broadway and 116th Street, showing the School of Business at the left.

for the meeting, the program as planned is presented herewith in brief. A complete description of the projected meeting has been sent you from the national office; the purpose of this article is to summarize and point up the program in such a way as to present a general idea of its character and vitality in relation to current events.

* Professor Kayan is in the Department of Mechanical Engineering at Columbia University, and is a member of the Publicity Committee of the Committee in Charge of Local Arrangements for the Fiftieth Annual Meeting.

As we explained in an earlier issue, this meeting has been streamlined to meet the needs and tastes of engineers at the present time, rather than to provide the conference combined with vacation of our past years. No official ladies' program has been organized, although we certainly guarantee welcome and entertainment to those ladies who do come; no plant trips have been scheduled because of government regulations as well as lack of time; all dinners

School of Mines of Columbia University.

will be informal and all discussions directly pertinent to the main question for all of us—the Task of the Engineering Colleges in the War Effort.

A glance at the program shows how basically the program for this meeting is connected with a much-needed analysis of our relation as engineers with the country's war against the Axis powers. The Army, the Navy, the War Production Board, the National Resources Planning Board, the Office of Scientific Research, the Office of Education—all vital arms of the Government for its blows directed against Fascism—are providing us with men expert in their work, to talk to us directly about the problems they face in their various tasks, and about the role of the engineer in helping to solve these problems.

Still further is the character of the meeting revealed in an examination of the conference programs offered. Every division and committee of the Society planning to get together this year has organized a program of discussion on specific problems connected with our basic purpose—the continual supply of well-trained engineers. Various details of our education of these engineers will be thoroughly discussed; discussed also will be details of the situation in which we are preparing them to take their part. Attendants at this year's meeting will have an unparalleled opportunity to discuss, discover and offer information and theories connected with the always important, but now vitally important, subject of engineering education.

The Local Committee has made every effort to have its arrangements worthy of the excellent program offered, and to provide as much relaxation and amusement as is possible at an annual meeting from which an organized entertainment program is, for obvious reasons, excluded. We can guarantee comfortable accommodations, good meals, pleasant living-rooms and lounges for moments of relaxation, and a large Hospitality Committee ready to welcome you when you arrive and to act as deputy-hosts during the weekend. Our Information Centers will maintain a file of events occurring in the City over the weekend, in case anyone has the time or inclination for a play or concert. One of the high points of the meeting will be the special service in the Columbia Chapel, which Chaplain Knox of Columbia is arranging for Sunday morning, June 28. And the annual Society dinner should certainly be no less pleasant this year because less formal; the speakers will be thoroughly attuned to the spirit of the meeting, and the events of the evening will be crowned by the presentation of the Lamme Medal. Monday morning's dispersal of conference groups to various of the host institutions will be marked by the opportunities extended to the members to examine and discuss the outstanding equipment available for engineering education in the New York metropolitan area, and will give as many as possible of the host institutions a chance to greet you at close hand.

The Local Committee is looking forward very much to welcoming you here for this annual meeting. We hope that as many members as possible will arrive on Friday evening, in order to be all ready to start at Saturday morning's session. It seems clear that the timely and complete program arranged for the weekend will make this a memorable, important and thoroughly enjoyable annual meeting; the host institutions assure you now that no effort on their part will be spared to help make it so.

Participating Institutions

Engineering Schools of the New York Metropolitan Area

College of the City of New York
Columbia University
Cooper Union
Manhattan College
New York University
Newark College of Engineering
Polytechnic Institute of Brooklyn
Pratt Institute
Princeton University
Rutgers University
Stevens Institute of Technology
Webb Institute of Naval Architecture
and the Middle Atlantic Section of S. P. E. E.

Headquarters

All of the meetings, with the exception of most of Monday's conference sessions, will be held at Columbia University, 116th Street and Broadway, New York City. Columbia has offered its full facilities in the way of meeting rooms, lecture halls, dormitories, and so forth, to the attending members and guests of the Annual Meeting. Transportation details for Columbia University are given under the special section on *Transportation* elsewhere in this resumé.

Registration will be at the Low Memorial Library during the sessions; early arrivals will be able to register at the special registration desk in John Jay Residence Hall on Friday, June 26, from 4 to 10 P.M.

All times mentioned are Eastern War Time, the only time basis now in effect in the East.

To Participating Institutions from Columbia

College of the City of New York

Subway

Northbound I. R. T. local or express to 137th St. station. Walk two blocks east along 137th St. Fare 5c.

Trolley

Northbound surface car at 116th St. to 137th St. and Amsterdam Ave. Walk one block east. Fare 5c.

Automobile

North along Broadway or Amsterdam Ave. to 137th St. East to the college.

Cooper Union

Located at Cooper Square in New York City.

Subway

Southbound I. R. T. express to Times Square; shuttle train to Grand Central; southbound local to Astor Place. Fare 5c.

Automobile

West Side Express Highway to 23rd exit. South to 14th St. Left turn into 14th St. and across town to 3rd Ave. Right turn into 3rd Ave. and south to Cooper Union.

Manhattan College

Subway

Northbound I. R. T. express marked 242nd St., Van Cortlandt Park, to last stop. The college is located on Spuyten Duyvil Parkway about 1500 feet from the station. Fare 5c.

Automobile

North along Henry Hudson Parkway across bridge (toll 10c) to 238th St. exit. Three blocks east to Waldo Ave. and north along Waldo Ave. to the college.

New York University

Transit

Northbound I. R. T. express marked 242nd St., Van Cortlandt Park, to 181st. Take elevator to St. level and then take eastbound surface car marked U to New York University. Fare 10c.

Automobile

North along Broadway to 181st. Right turn and across 181st Bridge. Left turn off bridge into University Ave. and north to New York University.

Newark College of Engineering, 367 High St., Newark, N. J.

Transit

Southbound I. R. T. express to Chambers St., Local to Cortlandt St. Station. Take Hudson-Manhattan Railroad train to Newark. Take subway to Warren Station and walk 3 blocks east. Fare 32c.

Automobile

South along Henry Hudson Parkway to Canal St. East to Holland Tunnel, then to Pulaski Skyway and Route 1. Just beyond Entrance to Newark Airport bear right to Newark, following McCarter Highway. Turn left on Market St. (central city) and right on High St. to the College.

Polytechnic Institute of Brooklyn

Subway

Southbound I. R. T. express to Borough Hall, Brooklyn. The Institute is located on the corner of Livingston and Court Sts., about two blocks from the subway station. Fare 5c.

Automobile

South along the Henry Hudson Parkway to Canal St. East along Canal St. and across the Manhattan Bridge. South to Willoughby St. and make right turn. West to Court St., left turn, and one block to Livingston St.

Pratt Institute

Transit

Southbound I. R. T. express to Hoyt St., Brooklyn. Dekalb Ave. surface car (eastbound) to Ryerson St. Fare 10c.

Automobile

South along Henry Hudson Parkway to Canal St. exit. East along Canal St. and over Manhattan Bridge. South along Flatbush Ave. extension to Dekalb Ave. (Paramount Theatre Building). Turn left on Dekalb Ave. and continue to Ryerson St.

Princeton University, Princeton, N. J.

Rutgers University, New Brunswick, N. J.

Train

Both of these colleges are best reached by the Pennsylvania Railroad. It is recommended that information on train schedules be obtained at the information desks at Columbia University.

Automobile

South along Henry Hudson Parkway to Canal St. East to Holland Tunnel. To Pulaski Skyway and Route No. 1 to New Brunswick or Princeton. Road maps will be available at the information desks.

Stevens Institute

Transit

Southbound I. R. T. to 42nd St. (5c). Take Bus No. 63 from Public Service Bus Terminal at 41st St. and 7th Ave. (Bus marked D. L. & W. Terminal, Hoboken). Bus goes down Washington St., Hoboken. Get off at 5th and walk one block east to Hudson. Fare 20c.

Automobile

South along West Side Highway to Lincoln Tunnel, through tunnel, then south on Park Ave., through Weehawken; east on 14th

St., Hoboken, to Hudson St. South on Hudson to 5th St. in Hoboken. Stevens Institute is located at corner of Fifth and Hudson Sts.

Webb Institute of Naval Architecture

Located at the corner of Webb and Sedgwick Aves., Borough of the Bronx, New York.

Subway

Northbound Broadway I. R. T. subway to 207th St. Walk east into Fordham Road (or take trolley along Fordham Road) to Sedgwick Ave. Institute is about half a black along Sedgwick, on the corner of Webb.

Automobile

Drive north up Broadway to 207th St., proceed as above.

INDUSTRIAL ARTS COURSES IN THE TRAINING OF AN ENGINEER

By E. L. WILLIAMS

Head, Dept. of Industrial Education, A. & M. College of Texas

In recent years I have read with interest many discussions pro and con on the evaluation of industrial arts courses in the training and preparation of an engineer. It was with regret that I found the following recommendation in the Progress Report of the S. P. E. E. published in the June 1940 issue of THE JOURNAL OF ENGINEERING EDUCATION:

> High school students contemplating engineering should be urged to study mathematics, literature, history, and English and omit manual training, mechanical drawing, bookkeeping, and the like now often recommended. If interest in reading is not developed before a boy is fifteen, it will be hard to interest him in social sciences in college and in the later self-development program proposed by E. C. P. D.

With due respect to cultural development, we must realize that the primary goal of the engineer is mechanical efficiency. Without this he will never need the English background for report writing and the broadening influences of literature and the social sciences recommended above. Present day mechanical efficiency and modern blitzkrieg methods demand concentration on manual and scientific exactness.

B. E. Nowotny has made an interesting study of the degree of success obtained in college engineering courses by students who have had industrial arts courses in high school in comparison with those who have not. He bases his findings on data taken from the four-year record of students who entered the Agricultural and Mechanical College of Texas in the fall of 1927.

Upon entering the Agricultural and Mechanical College of Texas each student is given a rating score—an aggregated index number of high school average and the psychological test grade. The purpose of this rating is to classify students according to their mental ability. The average rating score for those students who had industrial arts in high school was found to be 130.76 and those who had not had industrial arts was 132.51, a difference of 1.75 in favor of those who had not had industrial arts in high school. It

can be seen from this that at the beginning of their college course those students who had had no industrial arts courses in high school apparently had a higher mental level than those students who had taken such courses. Consequently better college work is expected from them.

In the School of Engineering during the four-year period a close correlation was found to exist between rating scores and grade points made per term; however, although those students with no high school courses in industrial arts had a higher average rating score, it was proved in a study of average grade points per term and for the whole four years that the students who had taken industrial arts courses in high school did better work throughout their entire college course. These students made a grade point average per term of 9.16 while the former made an average of 7.02 per term.

A separate study was made of the students enrolled in the Department of Electrical Engineering. This course is conceded to be the most difficult in the school. In a comparison of the four years' work of the two groups here, it was found that those students who had had industrial arts courses in high school averaged almost twice as many grade points per term as those students who had not taken such courses. The average of the first was 10.23 while that of the second was 5.84.

In a comparison of the four years' work of students in the Architectural Department of the School of Engineering it was found that here also the students who had had industrial arts courses in high school averaged more grade points per term than those who had not taken such courses, 10.94 rating above 9.00.

At the close of the four years a study was made of the graduates of this class. Again it was found that those students who had taken industrial arts courses in high school had a higher average of grade points than those students who had not taken industrial arts courses, the final comparison being 17.98 for the former and 15.84 for the latter.

From B. E. Nowotny's study it is self-evident that industrial arts courses in high school are valuable for fitting students for college engineering work. Although these students may enter college with lower rating scores than other students they do work of a higher quality through the entire college course than those students without such previous training.

P. W. Swain, editor of *Power*, has made the statement that people lull themselves dangerously when they imagine that men can become well-rounded engineers without first becoming good mechanics. In commenting upon the value of manual training he has advanced this opinion:

The planning of engineering work, and the designing of machines and structures, requires a "feel" for the materials and mechanical operations involved. It is impossible to acquire this "feel" except by actual work with the hands. Design is something more than an exercise in mathematical logic. To a substantial degree it is an art, an intuitive operation. Early direct contact with the medium is the most effective way to develop these intuitions.

This manual training need not be acquired in college but in high school, or better yet by working summers, or by a whole year of practical shop work between high school and college. I do say that it should be acquired *before* a man graduates from college. Afterward it generally is too late.

Some years ago when the engineering profession was interested in equipping its members to take their place in a society of peacetime building and development, the old classical ideas for their education held sway. Today when all America is engaged in a defense program which requires the utmost skill and efficiency of every citizen, mechanical expertness is the goal of the nation in the case of the directing engineer as well as in the case of the factory laboring man. If this efficiency can be raised by high school industrial arts courses, as has been shown through such surveys as that of Mr. Nowotny and through such contacts with the profession as those of Mr. Swain, certainly this phase of the public school curriculum in the preparation and training of engineers assumes a new importance.

SAFETY ENGINEERING TRAINING A GRADUATION REQUIREMENT

By A. NAETER

Head, Dept. of Electrical Engineering, Oklahoma A. & M. College

In the meeting of the Engineering Economy Section at the Boston convention on July 1, 1937, Dean Holbrook presented a timely paper on the "Economies of Safety Engineering." The discussions following that paper showed that there were some differences of opinion among the group present as to the necessity of a separate course on Safety Engineering.

At the Pennsylvania State College meeting in 1939 Professor M. S. Coover very ably discussed "Safe Practices in College Laboratories." He expressed the thought that the feeling was quite general that with such local conveniences as campus hospitals coupled with the fact that a majority of students have received extensive first aid instruction through various organizations such as the Red Cross, Boy Scouts, etc., the men will report promptly and voluntarily for treatment, even in the case of minor cuts and bruises.

Dean Seaton pointed out quite definitely and emphatically in the September 1941 issue of the S. P. E. E. Journal the need for safety engineering defense training. He named the steps that are being taken for reducing accidents in industry.

This change in emphasis on the needs for safety engineering, as it has appeared in the Journal, is rather interesting to the faculty at the Oklahoma A. & M. College. Dean Philip S. Donnell of the Engineering Division of the College, at one time a safety engineer in one of the large powder factories in this country, appointed a committee of three engineering faculty members over ten years ago to study this problem and to make recommendations. As a result of that study, training in first aid was made a graduation requirement for all graduates in engineering.

It was felt that once a man had had a tourniquet on his arm he would be much more acutely aware of the great desirability for avoiding the need of so drastic a treatment. This feeling would lead naturally into the field of accident prevention.

In view of the fact that a large proportion of the engineers from this college enter the mining industry, of which the oil industry is

considered a part, the U. S. Bureau of Mines was willing to send an instructor at yearly intervals to give this first aid training.

A few years later the work was expanded under the general heading of Safety Engineering. This work was divided into three parts, namely, First Aid Instruction, Physiology and Industrial Hygiene, and a series of lectures on Safety Engineering and Accident Prevention as Practiced in Industry. Safety engineers from the various oil companies and other industries have been glad to come to discuss various aspects of this important field. As a result of this work, well over a thousand engineering graduates have left the College trained in the basic fundamentals of safety engineering.

The members of the Engineering First Aid Committee have experienced much satisfaction when reports have been received of the saving of lives through prompt application of artificial respiration methods, the proper treatment of major injuries, etc. Numerous graduates have reported that once their respective employers discovered this training they were immediately put in charge of special classes dealing with various phases of this work. This relatively large group of engineering graduates is ready for and has been doing the type of work that Dean Seaton indicates as being essential in this national emergency. Employers look upon the possession of first aid certificates as an important qualification in their prospective employees.

While these first aid instructors were available in Stillwater, where the College is located, the local Fire Department coöperated wholeheartedly in organizing classes for residents in the community for this first aid training. As a result of this planned effort well over 800 people are trained for first aid emergencies in a town of about 10,000 inhabitants.

This work has been outlined as an illustration of the type of training that may be introduced into all of the colleges in the country. It has been in operation in the Engineering Division for a period of time covering a sufficient number of years to put it well beyond the experimental stage. The Oklahoma A. & M. College plans to continue the work as a permanent feature of the training of its engineering graduates.

THE INSTRUCTOR'S RESPONSIBILITIES IN THE LEARNING PROCESS *

By BRUCE V. MOORE

Head, Department of Education and Psychology, The Pennsylvania State College

The essential responsibility of the instructor in a learning situation is to see that the student progresses at *his* maximum rate toward attainment of ability for certain achievements. This general responsibility can be discharged more effectively if specific responsibilities are recognized. One of these specific responsibilities that must be recognized first is that of knowing the potentialities and possibilities of the learner for acquiring certain skills or developing power from knowledge. This means that the instructor must know the individual differences in the students, that he must learn the students before he can teach them.

A second specific responsibility is that of knowing how to facilitate the growth of the student toward achievement; that is, he must know something of the learning processes and the specific procedures which he can use most effectively in helping the student in the learning process. We shall consider briefly in this discussion these two main responsibilities; that of knowing the learner, and secondly that of knowing the learning process and methods of facilitating it.

The instructor needs to know individual differences, not only in order that he may work with each student according to his capacities and way of thinking, but in order that the instructor may set and maintain standards of achievement in his field of study or discipline. The instructor must assume in one way or another the responsibility of setting a critical or passing score or grade. In doing this, he must combine wisely a realistic acceptance of what the student can do and a discharge of his responsibility of giving society the best trained personnel available. That is, he must accept the student as he is and at the level of his achievement and help him to progress as far as he can toward a higher level of achievement. On the other hand, he must recognize that a certain absolute level of achievement must be attained if the student is to be recommended as one who can assume certain responsibilities after he has left the course or been graduated. If on the one hand any student is accepted and

* Presented at the meeting of the Allegheny Section, S. P. E. E., The Pennsylvania State College, November 15, 1941.

allowed to progress according to his own capacity, we should have the average of achievement lowered to that level which would be the average for the total population. On the other hand, if we set an absolute level of achievement for a passing mark, we run the risk of setting an arbitrary and impossible mark and failing to recognize what the real capacities of human beings are. The instructor, or at least those who lay down the policies for him, have the responsibilities of setting a mark which is attainable by a sufficient number of human beings to do the world's work on a professional level and at the same time recognizing that this mark must be always relative to what a normal selection of college students can attain. In the last analysis, there can be no absolute mark except that which is based on what students have done.

There is a place for objective measurements and a critical score or freezing out point. Human nature is often weak and willing to accept the symbol of achievement without the actual substance. Objective measures of actual achievement must hold the students to high standards of achievement, but on the other hand, the critical score must be set on the basis of what the students can do. The evidence for what students can do may include not only the current class being tested, but the experience with many classes. Thus the experienced teacher comes to feel that he knows what, for instance, a sophomore should do in calculus, but he must always recognize whether this is an arbitrary subjective opinion, or a justified conclusion from actual accumulation of scores on well calibrated measures. This means, in a concise restatement of this first responsibility, that we must know our students, start with them where they are, motivate each to his maximum capacity, and give him an accurate measure of his achievement, which is relative to what students can do.

The next specific responsibility of the instructor is that of facilitating the learning process itself. In order to do this, he must know something of the nature of learning. Concepts of learning, in their basic assumptions, may vary all the way from one extreme of mysticism to the other of naïve hard boiled materialism. The learning process may be looked upon, insofar as there is any clear thinking given at all to the question, as some sort of mysterious mental process in which the learner stores up certain knowledge and develops certain vague faculties of reasoning, analysis, or deduction. The other extreme would be to think of the learning process as that of merely formation of certain habits or physiological connections between sensory nerves and motor nerves. Both of these concepts are naïve over-simplifications and are inadequate.

For a working definition with which to start, let us say that the learning process is essentially that of making changes in the organ-

ism so that it can and will respond in ways that it did not respond before. If the student has learned, he can perform certain acts of skill, such as writing or drawing; or he can respond with certain ideas such as the number four when the situation two plus two is presented; or he thinks of a child when he sees the symbols *das kind;* or he may have an emotional experience different from those he ever had before after hearing an orchestra play a certain selection, or after he sees a highly skilled dramatic performance. There has been a learning or an educative process if he responds in ways that he did not respond before.

If there is a change in the organism, where is the change? Although some of this change may be in muscles, glands, and even the bones, the great part of it and the most essential part occurs in the nervous system, the connecting mechanism relating and integrating the various parts of the organism. Changes in this nervous system must be organic growth changes. We have no way of making mechanical changes, or very precise chemical changes that have any significant relation to learning. It is true that certain drugs will modify the sensitivity of the neurones, but this is a general change and not a specific kind of change producing one type of learning or response rather than another. In other words, the only way in which changes can be made in our nervous system is by having nerve impulses pass through the nervous system. These nerve impulses pass through the nervous system only when we actually perform the act to be learned or think through the idea to be understood and remembered. Thus it is absolutely true that we can learn only by doing. The only thing that the instructor can do is to set up conditions that are conducive to learning, which means that the only thing that he can do is to set up conditions that are conducive to getting the learner to react in the right way. The learning problem for the instructor, then, reduces itself to two practical questions. First, how can he get the learner to react in the right way; that is actually experience the right response? Second, after he has gotten the right response in one way or another, how can its reproduction be insured and fixed, in other words, remembered?

Let us look now at our first problem in the learning process. How do we get a right response? In the first place, we must have conditions such that there will be any response at all. In other words, there must be a desire to learn, a tension, a certain instability in the nervous system tending toward stability, a seeking for release of tension through a response. There must be a goal giving a gradient and experience of potential or tension. Anything the instructor can do which will make the goal definite, clear, vivid and appealing makes for conditions conducive to learning. There is no such thing as passive learning. Even persons sitting quietly listen-

ing to a lecture must be thinking along with the instructor. All the lecturer can do is to send out certain puffs of air that cause vibrations which we hope will reach the ear of the learner. We further hope that these vibrations will be recognized as certain symbols or words, and that there will be sufficient vocabulary and apperceptive background in the mind of the student so that certain experiences will be aroused by these symbols produced by these sound vibrations. Then only insofar as there is a cerebral response, an activity on the part of the student in thinking through the ideas for himself will there be any changes in his organism, and there certainly will not be any activity or changes in his organism unless there is some motive, tension, difference in potential, or gradient toward a goal. There is no learning without motivation. The more intimately connected with the material this motivation can be the better. Of course, there is some learning if there is only indirect motivation such as fear, on the part of a student, that he will fail if he does not go through certain operations which are more or less meaningless to a poorly motivated student.

The next problem for the instructor in the learning situation is that of helping the student find the route to travel toward his goal; that is, the problem of getting the right response on the part of the student. These procedures or methods may be classified into three: The simplest in the sense of the least skill required or the least help which the instructor can give, is that of learning by trial, error, and accidental success. This type of learning is not to be desired, but often it is the only method we have to make available to the learner. If the student is learning to write longhand or to draw, the only way in which he can learn is by trying many times and gradually eliminating his errors and increasing his successes. It does not help him for a teacher to take hold of his hand and guide it, except possibly to give him a little feel of the proper movement which he will be able to recognize later. His hand must respond, not because of some external force which moves it, but because of the nerve current which has been initiated in his cerebrum and sent out to his motor system through the nerves. The learning consists of the changes in the readiness of the nervous system so that fine adjustments in the strength and the particular pathway of the nervous current to the many muscles will make the precise movements required for this skill. This has often led to the oversimplified statement that practice makes perfect. Mere practice does not lead to perfection. This is sometimes observed in the small boy working with the copy book in which the writing becomes worse and worse as he nears the bottom of the page. Practice merely provides the opportunity for learning to take place. Learning takes place in practice insofar as there is a striving toward a goal and insofar as

the goal is definite and insofar as the approach toward the goal, that is the successes are recognized and the failures are recognized. A person shooting at a target and not knowing where the bullet hits cannot improve, except for possibly a little improvement in the method of squeezing the trigger and possibly the steadiness in holding the gun. There is no essential improvement in accuracy. On the other hand, a person may actually be improving in the learning process even though there is no apparent improvement. A boy who wishes very much to learn to be a baseball pitcher may throw the ball twenty times, ten of which go wild and are balls, and mingled with these are ten which are accurate throws over the home plate. If he is striving to improve and knows exactly when he failed and when he succeeded, he will reduce the number of failures and increase his successes. In fact, all twenty of his throws might be wild balls and still he would be improving if he were strongly motivated and knew when he went wild and when he approached an accurate throw. There would be a diminishing tendency toward and a gradual elimination of the wrong throws and an increase in the probability of his approaching an accurate throw, even though his practice throws all were wrong. On the other hand, even though his throws were all over the plate, if he were not motivated or did not know that they were over the plate, he might continue to practice with an increasing probability of wild throws. Any practice only provides the opportunity for learning to take place.

A more efficient type of learning than trial and error is that which is commonly called conditioning. If the learner is presented with a situation for which he has no ready response, he must seek a response by trial, error and accidental success; but if we can present a stimulus which is already associated with or leads to the right response, we may get the right response for this new situation. This can be made clearer by an example. If the words *das kind* appear before the learner, it would be a long time before he made the right response by mere trial and error. We present, however, the English words, *the child,* which are already associated in his mind with the meaning that we want him to have when the symbols *das kind* appear. Much of our learning is of this type in which we present an old stimulus to bring about a response that we want to occur following a new stimulus. This is essentially that of presenting the new in terms of the old. Great ingenuity can be used by the instructor in this type of guidance of the learner along a new route toward the correct response and the arrival at his goal toward which he is motivated.

Finally, there is what may be considered the highest type of learning, namely that which is by insight. In this we help the learner to develop certain concepts and techniques of solving prob-

lems. This can be illustrated by a simple case of insight and one in which the process or route of travel and thinking is more difficult. We can see by any inspection that two right angles are equal to a straight angle. This we say is self evident; the insight is immediate. However, the student does not see for the first time that the sum of the three angles of a triangle is equal to a straight angle. This is not self evident. The insight must proceed by an intermediate step in which a diagram of alternate interior angles or of exterior and interior angles can be seen super-imposed on the triangle, and then the three angles of the triangle will be seen to make up a straight angle. This process of solving a problem or meeting a situation by insight can be made clearer possibly by an illustration from animal learning, to which we often resort in giving an understanding of the learning process. A dog may run out of a box or pen toward his goal which is food, and in doing this he may turn to the left in order to arrive by the shortest distance to his goal. As the box is gradually turned clockwise, however, the dog will not continue to turn always to the left following his old habits. He will turn to the right when that provides the shortest distance to his goal, and he will do this immediately. This indicates that learning need not be a slavish following of habit, but can be a process of insight.

From our discussion of the nature of learning, we can now formulate a few very simple rules for learning, which, however, are so simple that they commonly are not recognized and thus are violated. The responsibility of the instructor is to see how he can most effectively apply or follow these simple rules.

1. Provide a genuine motive for learning—a goal that can be recognized and appreciated. Some of the most worthwhile goals may have to be relatively distant in space or time. The more immediate and vivid the goal, however, the more effective it is. Also the more related it is to the intrinsic nature of the subject being studied, the more effective it is. It may be necessary in some instances to depend on derived goals, such as grades or desire to remain in college, but there certainly must be a goal if there is to be a learning process.

2. The precise nature of the problem faced by the individual for arriving at the goal should be made as clear and specific as possible. This tells something of the route to be travelled. This precise nature of the goal and the route to be travelled should be made clearer by any devices available, such as actual demonstration of a process, diagrams, illustrative experiences or anecdotes, analogies, or exhibition of materials, objects, and pictures.

3. The learner should be informed as precisely as possible wherein he has failed and wherein he has succeeded, and this in-

formation should follow as soon as possible after the act. To hand back a paper and say that it is "a rotten piece of work" merely attaches annoyance to that subject of study and is even more ineffective if it comes several weeks after the work was done. To have someone watch me attempt to make a drive in playing golf and then tell me I sliced does not help me. I already know too well that I have sliced, but I want to know what made me do it. A good coach is able to diagnose more or less precisely what led me to slice. The good teacher in commenting on class work or in marking papers indicates as precisely as possible what is wrong and what is right and does not take these for granted.

Summarizing we can say that the learning process is a growth process which requires time and which the learner must carry on under stimulation. If we want to develop a tough skin on our hands, we say that we must use them, for instance, by shoveling or handling bricks. Such practice does not put on skin, it destroys it. If, however, we have proper nourishment and rest and guidance and wise use of our hands in such work, the practice or use of them stimulates the cells of the dermis or skin to grow more rapidly so that a tough skin will appear. Learning is a growth process which must occur in the learning organism itself, but it can be stimulated and helped somewhat if the instructor can understand and carry out with skill some of his responsibilities in setting up conditions conducive to learning.

FITTING ECONOMICS INTO THE THINKING OF THE UNDERGRADUATE ENGINEER*

By D. S. TUCKER

Massachusetts Institute of Technology

"Fitting economics into the thinking of undergraduate engineers" sounds as if it were the economics that were at fault. It assumes that the economics should be fitted and that the engineers should be regarded as a rigid container, incapable of expansion. If undergraduate engineers were really incapable of development, I would agree that the subject should be cut down and restricted to the level of a limited intelligence. It is because I am convinced that our difficulties lie neither in the subject nor in the calibre of the minds under instruction, that I have dared to open the discussion today.

In spite of this faith, it is with real trepidation that I undertake to discuss a subject on which conclusions must be so largely a matter of opinion. My opinions will be offered here chiefly in order to provide targets at which you may shoot in subsequent discussion. Your criticisms and corrections will be helpful to me as well as to others, but, because I hope to provoke such criticism, I propose to state my opinions very baldly, even though in some instances a defense of my position must depend on faith rather than on proof.

In many liberal arts colleges where students take economics only as an elective subject, classes in economics are normally crowded and the economics department in such an institution may be large. In many engineering schools, on the other hand, students resent even a modest requirement in economics, and courses in this subject are criticized. That the students who are interested in economics enroll chiefly in liberal arts institutions seems to me an inadequate explanation. Economics is in general an interest that students acquire after they enter college. Few freshmen, so far as I can learn, select a liberal arts college because they expect to major in economics. This condition suggests then that our troubles arise from the peculiar character of our teachers, our students, our courses or our institutions. Because outside criticism seems to be con-

* Revised in accordance with suggestions offered after presentation at the meeting of the New England Section, S. P. E. E., October 18, 1941.

centrated on the teachers and the texts, it is easier to start with these.

It has often been suggested to me that economics should be taught to undergraduate engineers by men who had themselves been graduated from engineering schools. The difficulty with teachers arises from an obvious source. To acquire a mastery of his subject, a teacher must have pursued graduate studies; but graduate courses in economics are offered usually in connection with liberal arts institutions. Even when offered in connection with engineering schools, such as M. I. T., these graduate departments draw their students chiefly from liberal arts colleges or from schools of business administration. Advanced work in our science demands usually a considerable background of undergraduate subjects, and few engineers take more than a single year's work in our field. Nominally all these graduate departments are open to bachelors of science in engineering who have had only very limited training in economics. Effectively such opportunities seem to be closed.

Only twice in twenty years, if my memory serves me correctly, has my own department at M. I. T. been able to appoint to teaching positions men who had graduated from an engineering school. That the success of these two men as teachers was due more to their personal qualities than to an engineering background has been demonstrated by their subsequent successes in other fields of endeavor; but it still seems possible that some portion of the quickness of their success as teachers may well have been due to a common background which they shared with their students.

Even if the quickness of success in these two instances had been due solely to an engineering background and to the use of engineering illustrations in class discussions, the question still arises whether this engineering background was a significant advantage to them after their first year? This I question very seriously. The three advantages allegedly possessed by engineers as teachers of economics are (1) a capacity to illustrate economic principles by the use of engineering data, (2) a capacity to command greater respect from students because of an engineering background, and (3) a capacity to teach in some different and more scientific manner. Each of these allegations will be examined briefly.

(1) The first year of teaching is difficult at best. That first year, if spent in teaching economics to engineers, is extraordinarily difficult for the graduate of a liberal arts college. Good teachers, however, study their students. A teacher learns very quickly to draw his illustrations from fields that are familiar to his students.

(2) Budding engineers like their teachers to have an engineering background. The "consciousness of kind" described by Giddings is a very real force; but "like-mindedness" causes friendliness

rather than respect. Respect arises from the teacher's character and his mastery of his subject. It is true, however, that the liberal arts graduate must make a greater effort to secure the coöperation of his students. This effort is not impossible.

(3) The engineer teacher of economics might also present his subject in a different manner; but no two teachers probably were ever watched more closely than I watched the two engineers who for some time taught in our department. Their methods were those of any good teacher of economics. Certainly they were neither more mathematical nor more precise than the other teachers on our staff. They were, it is true, highly successful; but in my opinion their success was due to outstanding personalities. Business school and liberal arts graduates with forceful and pleasing personalities are also successful in teaching undergraduate engineers.

My conclusion is that an engineering background would be helpful in teaching economics to engineers; but it should not be accepted in place of other qualifications when making appointments. In a sister institution at one time the desire to have an engineer teach economics led to the appointment of a man insufficiently trained in the science he was supposed to teach. Students from that institution on transferring to M. I. T. revealed clearly the inadequacy of their training in our field.

It has been suggested to me also that the text-books in economics should be written in a different style. Here outside criticism may have a somewhat better basis in fact. Our text-books for the most part have been written by men who teach in liberal arts institutions. Teachers of economics in engineering schools are few in number. Still fewer are those who have the light teaching loads that prevail in some liberal arts institutions. In spite of these facts two of the most successful texts ever written, those by Francis Amasa Walker, came from an engineering school. These two texts, however, illustrate well the last and most significant of our sources of difficulty with text-books.

The number of students registered for courses in economics in liberal arts colleges and in schools of commerce exceeds greatly the number so registered in engineering schools. Authors of texts are substantially compelled to adapt their books primarily to the needs of the average reader. The average reader of an economics text is not an engineer. This text-book problem our department at M. I. T. hopes some day to remedy; but at the present time it must be admitted that all the better known texts on economic principles are written primarily for students of the non-engineering type.

Why should the text-books prescribed for engineers differ from those prescribed for liberal arts students? What are the characteristics of undergraduate engineers that set them apart? It seems

to me that six attributes of the typical undergraduate engineer can be clearly distinguished.* Of these six attributes, two are helpful; but the others create difficulties.

The first attribute is a high native intelligence. For some years Professor McGregor of our department at M. I. T. has been giving intelligence tests to the students in one of his general studies. This general study draws its enrollment from all departments of the Institute, so that results found with respect to this group may be regarded as a fair sample of Institute undergraduates. The test used was the Wells Alpha. This is a modification of the Army Alpha test. The modification devised by Professor Wells fits it for use with superior adults. Scores attained on this test are nevertheless directly comparable with scores on the Army Alpha test. The possible range of scores on the Wells test is from zero to 212. Scores attained by Institute students ranged from 120 to 200. The average score for our students was 167.0. In a sister engineering school in a different state student scores on this test ranged from 120 to 185, and the average was 157.7. Even if averages in the untested engineering schools should prove to be somewhat lower, it seems quite possible that undergraduate engineers may on the average rank above 150 on this test.

The significance of a grade higher than 150 may be indicated by two comparisons. Under Selective Service Acts an army becomes a fair cross-section of the literate population. The average grade for members of our army on this test was 61.0. This 61 may be compared directly with grades in excess of 150. College graduates, however, are a selected group. For college graduates in the army the average grade was 130.0. This grade of 130 is also probably fairly representative of American college graduates in general. The figure, 130, may therefore be compared directly with the grades in excess of 150 attained by undergraduate engineers. Our students in general are obviously highly intelligent.

The second attribute of our students is best revealed by a comparison of two portions of an aptitude test. It became possible to conduct intelligence tests on students in a liberal arts institution of extremely high standing. In this institution students attained an average grade of 160.3 on the intelligence test. Students in this particular liberal arts institution were therefore of sufficiently high grade to be used as "guinea pigs" for comparisons with engineers. The purpose of the study then undertaken was to compare aptitude in *numerical* tests with aptitude in *verbal* tests. The results proved to be significant.

On tests involving a capacity to handle numerical calculations, M. I. T. undergraduates averaged 163.7 and students in the other engineering school averaged 164.8. Students in the liberal arts

college averaged only 147.0. Undergraduates in engineering schools, as might be expected, are self-selected from among boys that find numerical calculation easy. It is not surprising therefore to find budding engineers somewhat superior to liberal arts undergraduates on tests measuring mathematical aptitude.

Verbal tests, however, form presumably a better measure of capacity in economics; and it is in connection with these that the most interesting result arises. On these verbal tests M. I. T. students averaged 168.5, students in the selected liberal arts college averaged 166.0 and students in the sister engineering school averaged 154.1. Differences among these students in their native capacity to grasp verbal material are smaller obviously than differences in their native capacity to handle figures, but it is obvious also that superior mathematical aptitude is not necessarily balanced by any inferiority along other lines. Engineering students are or should be as able as any group of liberal arts students to understand economic principles.

The third attribute of engineering students is less helpful. Our students in general are woefully ignorant concerning ancient and mediæval history and often with respect to modern history also. In preparatory schools, as well as in high schools, science courses are offered frequently as alternatives to courses in history. In the college preparatory courses of many excellent secondary schools students are either urged or required to take English, mathematics and a foreign language. Such students take normally four subjects each year. The fourth subject may be history, a science, a second foreign language or perhaps drawing. College preparatory students who are interested in science can usually get courses in biology, physics and chemistry; but election of these sciences diminishes normally the amount of history they study in the secondary school. Our students have in general therefore taken less than the average amount of history while in preparatory school.

In many liberal arts colleges a course in mediæval and modern history is required in the freshman year. In a liberal arts college a sophomore who enters economics, has often already started his second college course in history. Few engineers take more than a single year's work in this field. His collegiate as well as his preparatory school training in history is thus abbreviated. This double deficiency in history is serious on several counts. Present-day public problems have their roots in the past. Economic science attempts to contribute toward the solution of these problems; but the contributions of economics may have but little meaning to the student who has no appreciation of the significance of the problem. It is extremely difficult for a student who knows little about the

history of our institutions to become seriously interested in public problems that involve those institutions.

Deficiency in mediæval history is in my opinion especially serious. Economic institutions of the Middle Ages differed from those of today. Our institutions are now changing, much as they changed during the breakdown of the Middle Ages. To the man without training in history, this alteration of our institutions is immoral, much as the introduction of steam railroads was immoral a century ago. To such men a discussion of alternative directions of change seems futile. To the man trained in history, changes even in our institutions seem natural and inevitable. He is prepared for a comparison of alternative methods of change. Many of the discussions in economic texts, such as typical chapters on the control of monopolies, assume tacitly that evolution of some kind is both inevitable and controllable as to direction. In engineering schools teachers of economics are compelled to teach students that public problems exist and are significant, as well as to train them in methods of analyzing such problems.

The fourth characteristic of our students is related to the third. Our students have not been trained in rapid and extensive reading.* In some engineering texts almost every word is highly significant. Ideas in history and in economics cannot be presented so compactly. Even if our present requirement of English and history at M. I. T. served no other purpose—and it serves many others—it should in my opinion be retained for the sake of the training it gives our students in reading. Such training will be valuable to them in many other connections during later life. Students who elect science in high school and then come to an engineering school receive far too little training in the art of abstracting ideas from paragraphs.

The fifth characteristic of undergraduate engineers is an amazing lack of knowledge about business practice. Our students know much about production; but they know very little about business. In a liberal arts college or school of commerce there are normally many students who have worked during the summers as office boys, sales clerks or collection agents. A few may even have served as book-keepers. Summer jobs of these types give their holders some insight into profit-making and business policy. In an engineering school many undergraduates have held summer jobs in testing laboratories, research divisions or production departments. None of these jobs will have brought them, even remotely, into contact with the financial or money-making aspects of business. The narrowness of such experience tends to focus their attention on the production of goods, and to render them unmindful of the problems of business.

From what has been said, it follows that, if abilities are contrasted with interests, the typical budding engineer has abilities that would make him a good president or general manager, but he has frequently the interests that tend to make him a good foreman or division superintendent. The very difficulty of engineering subjects tends also to strengthen this absorption in the narrowly technical aspects of production. An undergraduate in some liberal arts college, on the other hand, may have only the ability necessary to become a good foreman; but he may have interests and a view-point that might lead him eventually into the president's chair. The duty of an economics department is of course to train students in economic thinking; but in an engineering school there is also a superior obligation. This is to awaken students to the existence of business as an institution that includes far more than production.

The narrowness of the experience of typical undergraduate engineers is remarkable. Many of them have no specific knowledge concerning any kind of business except manufacturing. If a typical manufacturing enterprise is divided into four departments, three of these (marketing, accounting and finance) are usually terra incognita to the young engineer. If the fourth department (production) is divided into purchasing and manufacturing divisions, the work of the purchasing division is also usually unknown. Within the manufacturing division of the production department our students are usually familiar with research and operation, but other phases of this division, such as personnel administration, are also usually unknown.

In many liberal arts colleges the experience of undergraduates has been more catholic. The efforts of an economics department in such colleges may therefore be supplemented by much mutual education among students. For this reason our task is far greater than that of the economics department in many liberal arts colleges. Putting it numerically and assuming equality among the different sections of business, our students are aware of the existence of about 9 per cent (that is, $\frac{2}{3}$ of $\frac{1}{2}$ of $\frac{1}{4}$) of the problems of managing a manufacturing enterprise. With respect to the other 91 per cent of the problems of business administration, we must teach them that the problems exist, as well as how to approach a solution. No student is much interested in learning how to solve a problem that in his opinion does not exist.

A sixth attribute of the undergraduate engineer is a naïve philosophy. Naïve philosophies are not peculiar to engineering schools; but in many colleges of other types the students bring with them a wide variety of naïve philosophies. It follows therefore that "bull sessions" attended only by students operate in some colleges to break down the faith of each student in his own par-

ticular brand of naiveté, and to render his mind a more fertile ground for planting the seed of a more rigorous analysis. In an engineering school so many students suffer from the same brand of naiveté that "bull sessions" among them tend apparently to strengthen the beliefs already held. The hold of economic superstition on the engineering mind is thus entrenched.

Some aspects of this great superstition may be mentioned here. (1) Many young engineers believe that prices are determined chiefly by costs. This half-truth seems to arise because cost is the one aspect of business that impinges regularly on engineering practice. (2) Many young engineers believe that high wage rates cause high costs of production. The prevalence of this half-truth among men whose business it will be to alter output per man hour seems almost incomprehensible, even though they may be forgiven readily for a failure to appreciate the importance of procurement policy and other elements of cost. (3) Many young engineers believe that standards of living directly determine wages. A corollary of these beliefs is of course a naïve faith that American prices are higher than European prices and that prices in northern sections of the United States are necessarily higher than prices in the South. Other elements of this great superstition are probably familiar to you all. These three illustrations, however, are sufficient to suggest that the mind of the undergraduate engineer is not fallow ground. It resembles rather a neglected pasture lot which is now filled with shrubs and saplings that must be grubbed out patiently one by one.

The task set for an economics department is to train students to think accurately on economic subjects. The time allowed for this purpose is usually less than 5 per cent of the student's total class hours while in school. That we fail in many instances to accomplish our task is a foregone conclusion. If in the remarks that follow I describe chiefly our experiences at M. I. T., it will not be from any belief that we have found the correct method, or even a satisfactory method, of doing our job properly. We are still struggling. Our experience may nevertheless be useful to others by suggesting some of the pit-falls to be avoided. However far we may still be from our goal, we thing we have learned a few things about the road. Nevertheless, the conclusions that I shall offer here are personal opinion only. There are points on which even some of my own colleagues would not agree with me. These opinions are presented merely as my conclusions from our experiments. As such, the conclusions follow.

1. This particular subject when taught by senior members of the staff is more effective than when taught by young instructors. Professors have frequently a wider familiarity with the applica-

tions of economic principles than do young instructors. That some professors may also be doing work of a more advanced type is quite beside the point. The undergraduate cannot delve very deeply into any field. The quality valuable here is the capacity to answer a student's question and in that answer to cite an appropriate application or illustration of the point elucidated. It should never be forgotten that in teaching engineers we must convince students that our principles are significant as well as strive to make them clear.

In recent years at M. I. T. we have had the ablest group of young instructors that I personally have ever known; but I still think regretfully of the time when sections in elementary economics were taught by two full professors, two associate professors, two assistant professors and one instructor. Professor Dewey who is known to most economists for his scholarly publications or for his editorship of the *American Economic Review*, is known to many graduates of M. I. T. chiefly as a beloved and successful teacher of elementary economics. In these days of economy and of a diminished yield on investments, the use of senior members of the staff for elementary instruction is difficult or impossible; but it would be hypocrisy not to recognize some of the values of a by-gone era.

2. In years past we have at different times offered elementary courses covering 45 class hours, 60 class hours and 90 class hours. The two shorter courses were in our opinion thoroughly unsatisfactory. Students were compelled to ingest principles so rapidly that they suffered from mental indigestion. Examination answers were parrot-like. Students memorized the words; but failed usually to absorb the meaning of our principles. Little power to analyze economic problems was developed or could be developed in so brief a time. The human mind cannot master a new technique quickly. At the present time only one introductory course is offered at M. I. T. Classes in that subject meet three times a week throughout the whole year.

Because students come to M. I. T. from institutions that still offer shorter courses, I have occasion frequently to discover that students elsewhere suffer from the same difficulties. No matter how perfect the teaching, the short course in economic principles is in my opinion necessarily a failure. I raise therefore this question. If the time that can be spared for economics is less than 90 classroom hours, would it not be wise to substitute for economic principles some simple description of business practice? At least two excellent descriptive texts are available. Such texts would supply for engineering students what summer experience in business offices and casual conversation with other students supplies for many liberal arts students. A simple descriptive course would fill a

serious gap in engineering education. Presentation of such material would also relieve some departments of a feeling of failure. They would no longer be attempting the impossible.

3. The elementary course in economics has been offered at M. I. T. to second-year, to third-year, and (in one instance) to fourth-year students. Occasionally a first year student is admitted by his registration officer. We have had opportunity therefore to note the effect of maturity on a student's capacity in economics. Our conclusions on this subject are two. (*a*) Each additional year of maturity enlarges the student's capacity to grasp economic principles. (*b*) The greatest advance is made between the second and third years. A comparable development of the student's power has been noted, I am told, in some liberal arts institutions.

For students who plan to do more advanced work in economic subjects, delay of entrance into the field may well be unwise. The gain in analytical power in the elementary subject may be more than offset by losses due to an excessive concentration of the advanced subjects; but for those who can take only one course, delay of that course until the third year seems highly desirable. For this reason we are at M. I. T. striving to maintain a standardization of the subject in the third year for all students who will do no further work in our field.

4. In an effort to make students understand the reading assigned, we attempted at one time to find easy texts and to give short assignments. We entered thus upon a hopeless and losing race. If students regarded our assignments as easy, they diminished accordingly the amount of time allotted to the study of economics. No matter how short the assignment, the student effort was always less. Finally in one year a few students attempted to delay reading the text until a week before the examination. The results were so disastrous for them that we reconsidered and reversed our policy.

In one sense we still try to make the subject easy; but we no longer pick texts that avoid the difficulties. We try now to face the problems squarely and to clear up the difficulties as best we can. At the present time Institute students may fail to like economics. Many of them still fail to see why they should be expected to take such a subject; but we believe that students now respect the subject. They recognize in it a body of principles as definite as those found in natural science, even though they recognize also that observations or data may deviate from the mean more widely than in any field of engineering science save only perhaps in some portions of strength of materials.* If my department has learned one thing above all others in the last 20 years, it is that we need not apologize for our science.

5. Because economic principles can in some instances be demonstrated by the use of calculus, and because our students had taken courses in that subject, we tried at one time to present certain economic principles through the use of mathematical methods. Our attempt was a failure. We found that a few students had forgotten the portions of calculus that were useful for our purposes. It was necessary in some instances to review the mathematics. After the mathematics had been demonstrated, all students seemed to have great difficulty in converting the mathematical symbols back into ideas. We found that the mathematical demonstrations were largely meaningless to undergraduates. Progress in economics was slow.

Use of mathematical methods seemed to fail as a teaching device chiefly because the concepts that economists represent by symbols are more difficult or more complex than speed, acceleration, force or the other concepts of the physical sciences. A rate of change in human choices when plotted over price seems to puzzle undergraduates more than a rate of change in velocity when plotted over time. In teaching economics to students untrained in business one of our greatest tasks is to make sure that every student understands clearly at every minute just what we are discussing.

6. Even though the experiment with formal mathematics failed, it had back of it the germ of an idea. Undergraduate engineers like terse, concise statements. They like also precision of statement. Even though verbal teaching of economics is more effective than the use of mathematical symbols, some closer approach to mathematical rigidity seemed desirable. For many liberal arts students the principles can be made easy by avoiding rigidity of formulation. For budding engineers some rigidity of formulation seems actually to aid comprehension.

7. In this connection two fairly recent contributions to economics permit the demonstration of elementary principles more readily to engineers. Joan Robinson and Edward Chamberlain have worked out in mathematical form the mechanics of output and price. The concepts of monopolistic competition are difficult for liberal arts students. We have found them a great help in teaching engineers.

In connection with business cycles also we have discovered in an experimental section that the multiplier concept of Mr. Keynes seemed similarly to facilitate student comprehension of the nature of business recovery and recession. We are considering now methods of introducing that concept into our big elementary course.

At every point at which we have experimented, the results secured have in my opinion warranted a conclusion that the more closely we approach mathematical methods of presentation, the

better are our results, *provided* we do not use mathematical symbols.

8. When compared with a typical class in a liberal arts institution, undergraduate engineers bring into their first class a higher ability; but they bring also a far greater ignorance. In my opinion it is because of this ignorance that so many students are indifferent or scornful in their attitude toward economics. Certainly the more knowledge of economics they acquire, the more does their indifference disappear; *but* it is only by forcing them to learn something that we can induce them to become eager to learn. For this reason I personally would recommend also fairly frequent written tests, some stiffness in grading and some courage in reporting failures and in compelling students to repeat the subject.

9. The use of case material similar to that prepared by the Harvard Business School seems to aid engineering students in comprehending the meaning of our principles. Such case material presents to young engineers the business problems that summer jobs in sales or accounting departments may present to others. In an experimental section Professor Maclaurin of our department has found that the use of business cases was very successful in arousing the interest of students. For this reason we are now introducing a certain number of such problems into our big elementary course.

10. Finally I would suggest a point which I have not yet discussed with my associates. It seems nevertheless important to me. Our greatest obstacle in the teaching of elementary economics, it has been suggested, is a lack of interest on the part of students. This lack of interest arises from causes already mentioned and also in my opinion from the fact that few undergraduate engineers are able to pursue more advanced studies in economics.

It is easier to teach any subject well in an atmosphere or community where many have already acquired some proficiency. Students taking their third or fourth year's work in any field may occasionally help a fellow student over some of his difficulties; but the chief service of more advanced students in an undergraduate body is of a different kind.

To undergraduates pursuing more advanced courses in any subject, the principles taught in the elementary course become important. In more advanced courses they see these principles applied. Because they thus see the principles work, their attitude changes. The principles acquire new significance and meaning. This sense of the importance of the subject they transmit to underclassmen, even though they may fail to transmit any specific knowledge.

Principles that have no significance are necessarily an object of suspicion in any community, whether this lack of significance arises through the fault of the principles or the fault of the community.

In engineering schools few students carry their study of economic principles beyond the elementary stage. Principles of economics in such schools lack therefore the sanctions of verification and application. They lack also for this reason the support of student opinion. The single year of economics resembles to some extent a brief course in chemistry where laboratory work is omitted. Under such conditions chemical principles also might fail to arouse interest among students.

Teachers of elementary economics in schools where some advanced courses are also offered, possess a great advantage over teachers in schools where only a single course is presented; but in all engineering schools the principles of economics are at a hopeless disadvantage before the bar of student opinion when compared with the principles of physics. No amount of progress in our science and no amount of improvement in our technique of teaching can wholly overcome this obstacle. It lies in the nature of the human mind. The only remedy possible in an undergraduate body would probably be to have students of engineering enrolled also in a school of commerce. Since this remedy is normally impossible, the principles—and perhaps even the teachers—of economics will necessarily fail to secure the whole-hearted support of student opinion. This obstacle to the effective teaching of economics, I shall assume, is unalterable. It must simply be accepted.

Do we not, however, owe to our associates in other departments some obligation to make them understand the nature of our problem even if we make no proposal for the alteration of any academic curriculum? Satisfactory revision of a curriculum may well be difficult or impossible. Would not merely a more general comprehension by our confreres of the nature of our difficulties be helpful in many small ways? This last suggestion has never been tried out in my institution in any systematic way. Nevertheless, I am wondering if it does not contain some validity.

Specialization necessarily involves the danger of narrowness.* The economist is just as narrow as the engineer. He may even be narrower because there are many areas within his field concerning which he knows very little. Present economic science is admittedly narrower than the field it has marked out for itself. Business with its absorption in profit is also narrow. If socialism were to happen to us, business, as we understand it, would disappear. Part of our economics would also become obsolete; but engineering would remain at least as important as it is now. What I shall say next is therefore not a criticism of engineering or of engineers. It is, however, a criticism of undergraduate engineering students. Their viewpoint is narrow.

The study of economics is broadening for engineering students in exactly the same way that a course in natural science would be broadening for students who have majored in social science or in Greek; but it is not the cultural values that I desire to emphasize first. The immediate problem is narrower. It arises in connection with business administration rather than in connection with the more professional aspects of my science. Engineering science covers only a very small percentage of the problems of business policy. Could not the teachers of engineering help us to make students realize that business success demands more than a low cost in manufacturing operations?

Of a dollar spent by a family for the typical manufactured good about 59 cents, it is estimated, goes into the various costs of marketing that article. Of the remaining 41 cents more than half goes apparently into procurement costs. Possibly only about 18 cents of the typical consumer's dollar, as far as I can learn, is on the average devoted to the manufacturer's internal costs; and these internal costs include record keeping and other elements as well as operating expenses of the types that are based on engineering. With respect to processing costs the engineer, it should be admitted frankly, knows more than the economist will ever know; but business expenses are chiefly of other types, and business success depends also on good financing and a good demand for the product. Could not teachers of engineering help us greatly by suggesting occasionally during office consultations that business includes more than the operating division of a production department?

Could we not from such coöperation secure some of the values that some schools have tried to gain by searching for engineers who can teach economics? Would not such a suggestion be more effective if it came from an engineer who taught engineering rather than from an engineer who taught economics, even if the latter could be found? Do not the teachers of engineering have an interest much like our own in correcting this narrowness of viewpoint among students?

Do not many teachers of engineering recognize also, just as clearly as any economist, that a useful life includes good citizenship as well as business efficiency? Economics is included in engineering curricula because it broadens the student's interests as well as because it provides him with a much needed technique of analysis. As economists we can be proud of present economic techniques; but can we not admit that our science is broadening for young engineers chiefly because it is so different? Could not teachers of engineering, if their attention were drawn to this problem, become as interested as we are in broadening the vision of their students? Could they not also help us greatly by suggesting more frequently to students the value of good citizenship?

COURSE CONTENT IN AIRCRAFT STRUCTURES

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Introduction

The overwhelming importance of the air force in the present war caused a great increase in the demand for aeronautical engineers and for teachers of aeronautical engineering. The question, therefore, arises: How can structural engineers and teachers of structural engineering become useful in aeronautics? The purpose of this meeting is to give an answer to this question, and this paper endeavors to make a contribution toward this goal by discussing the requirements for the course content in aircraft structures.

At the outset the meaning of the term aircraft structures should be defined. In present day usage aircraft structures denotes the science that treats of the calculation of the stresses in the airplane, if the external forces acting upon the airplane and the geometric and mechanical properties of all its parts are known. It includes, therefore, topics dealt with in theory of structures, strength of materials, and theory of elasticity. Most textbooks also contain chapters on the determination of the external loads. This last matter will not be considered in the present paper since in the writer's opinion it can be handled better in a course on aircraft design or applied aerodynamics.

Differences Between Civil Engineering Structures and Aeronautical Structures

It is obvious that the laws of statics and of elasticity are the same whether they are applied to bridges or airplanes. Therefore, a good structural engineer with a broad knowledge of general principles and basic methods will not find it difficult to change over to aeronautical structures. Numerical and graphical methods for solving routine problems of aircraft structures can readily be learned by any one who commands a good knowledge of the underlying principles. Nevertheless, there is one fundamental difference

* Presented at the Aircraft Structures Conference, New York University, September 5 and 6, 1941.

which sets apart aeronautical structures from civil engineering structures: the former are very much lighter than the latter. The reasons for this difference are that the loads acting upon the airplane are comparatively small, and the importance of saving weight in airplanes is much greater than in any other structure.

The effect of light construction upon stress analysis is twofold. First, in order to keep down the weight and yet attain the necessary safety in operation, many secondary effects, likely to increase or to decrease the strength of the structure, must be considered which could well be neglected in the strength calculation of heavier structures with correspondingly greater safety factors. Secondly, the trend toward light weight has resulted in structural elements of such slenderness and small wall-thickness that several generally made assumptions of the strength of materials are invalidated, and problems related to elastic stability attain a paramount importance.

As a first illustration of the complications arising in aircraft structures, the continuous beam on several supports is considered. In the classical solution, known as the Three Moment Equation, the influence of axial forces in the beam is not taken into consideration. Such a procedure, as a rule, is correct with civil engineering structures. If, however, the slenderness of the beam and the axial forces acting upon it are great, the bending moment distribution, the stresses and the deflections may differ considerably from those obtainable by the classical Three Moment Equation. Such was the case in the wing spars of the biplanes of the First World War for the calculation of which entirely new routine procedures had to be and were developed. This might perhaps be considered the beginning of an independent science of the stress analysis of aircraft.

Similarly, when the Hardy Cross method of moment distribution was applied to the calculation of bending moments in aircraft frames, it turned out that neglecting the influence of axial forces in the bars often led to erroneous results. For the purposes of aeronautical engineering it was necessary to develop methods by which this influence could be taken into account.

Another typical modern aeronautical problem is the buckling of monocoques. Monocoque or stressed-skin structures are those which rely upon the covering to resist and transmit shearing forces, and also part of the longitudinal forces. Monocoques consist of the external covering and of the longitudinal and transverse reinforcing elements, called stringers and rings, respectively. In the case of monocoque structures Professor von Karman and his collaborators set forth the following classification of the types of buckling:

1. Buckling of the stringers between adjacent rings in a way similar to ordinary column failure.

2. Local failure. This might involve the giving way of an unsupported leg of an angle section used as a stringer or ring, or the formation of waves in the thin-walled back of a channel section used for the same purpose.

3. General type instability. This is a type of buckling in which several stringers, several rings, and the covering are simultaneously involved.

In addition to these possibilities the aircraft stress analyst has to keep in mind the buckling of the panels of sheet between reinforcing elements and the local buckling of a strip of sheet between rivets. These both result in a reduction of the capacity of the structure to carry loads.

Furthermore, the aircraft stress analyst is frequently called upon to calculate redundant structures. The times, of course, are past when civil engineers and architects were allowed to strive to design all their structures in a statically determinate way. Notably modern reinforced concrete structures led to the introduction of involved methods of stress analysis of highly redundant systems.

Redundant structures are, however, of even greater importance in aircraft for two reasons. First, if by a redundant design even a very small increase of strength can be attained, the resulting material increment in the work of analysis is considered worthwhile in view of the importance of saving weight. Secondly, as already stated, more accuracy is generally required in stressing aircraft than in stressing structures of other branches of engineering. However, the stresses in actual structures are always statically indeterminate, and their calculation can be reduced to problems of statically determinate structures only by often far reaching idealization. The aircraft engineer is allowed to use such abstractions or simplifications to a lesser degree than the structural engineer, and consequently he must be well versed in the use of strain energy and other methods for the solution of statically indeterminate problems.

This short review indicates that the problems of aircraft structures are basically the same as those of structural engineering. The viewpoint of the aircraft stress analyst, however, differs somewhat from that of his structural colleague because of the importance of light construction and the effects of the resulting slenderness and thin walls of aircraft structural elements.

The Needs of the Aircraft Industry

After this account of the main distinguishing features of aircraft structural analysis, it is interesting to investigate what knowledge the aircraft industry requires of the young engineer. Fortunately this question was dealt with in detail in a lucid article by

C. T. Reid, Director of Education, Douglas Aircraft Company, entitled "What the Aircraft Industry Expects of the Engineering College," presented at the 9th Annual Meeting, Pacific Southwest Section S. P. E. E., December 27–28, 1940, and published in the March 1941 issue of THE JOURNAL OF ENGINEERING EDUCATION. The article shows what knowledge is held essential by the employer, and this must be considered, of course, by the college and by the young engineer if he is to get a job.

According to Mr. Reid's table, only 65 of the 1155 engineering employees of his company are engaged in stress analysis and structural design. These 65 men have to perform the duties of testing completed units and airplanes, and of strength-checking detail drawings of all vital parts, in addition to the stress analysis work proper. The number seems to be rather low, if development work is being carried out. One would assume that the percentage of the employees in this department was greater at the time when the first all-metal Douglas planes were designed.

According to Mr. Reid's paper about 6 per cent of the employees in the engineering department need a thorough knowledge of structural analysis and about 62 per cent of them should have a sound foundation in the stress analysis of simple structural elements. In the writer's opinion these statistical data well emphasize the importance of a good basic training in engineering mechanics and strength of materials. They do not prove, however, that the teaching of more advanced theories and methods is unnecessary. The aircraft industry certainly needs a greater number of young engineers with skill in simple stress analysis coupled with good practical sense, than theoreticians who can only warrant the correctness of their mathematical deductions but lack ability to correlate theory with practice. For this reason the engineering college should endeavor to develop a sound engineering judgment in the student. It cannot, however, abandon the teaching of theory without usurping the vocational school's field and forfeiting the student's chance of becoming a leading personality in the profession.

Even if at present the aircraft industries' main objective is production, research and development must not be discontinued. But this is not the only field where a theoretical knowledge is required. The man with a sound theoretical background will be at an advantage in most practical jobs. In this connection the importance of employing engineers well versed in both theory and practice for all kinds of testing cannot be overemphasized. Some so-called practical men sneer at all theoretical considerations and at the same time accept test results with awe even if the methods by which they were obtained are dubious, or little known. Good tests

and the right evaluation of the effects of unavoidable deviations from reality can only be obtained from practically competent and theoretically well-trained engineers.

Difficulties in Establishing a Curriculum

Naturally the difficulty in establishing both a curriculum for aeronautical engineers, and the course content in aircraft structures does not lie in what to include but rather in choosing the items which can be omitted. At present it is hard to put even the absolutely necessary subjects into the crammed curriculum of an aeronautical engineer.

In this country two systems are generally used by the colleges for training aircraft engineers. In one, the principal aeronautical subjects are given in a one-year post-graduate course after a four-year mechanical engineering curriculum has been completed. In the other, some of the conventional mechanical engineering subjects are shortened or eliminated and special areonautical subjects substituted so that an A.B. degree in aeronautical engineering can be awarded upon completion of the four-year curriculum.

In both cases the course in aircraft structures is destined to complete the training of the engineer-to-be in the structural and stress analyses of airplanes, and thus the instructor must feel responsible for the ability of his students to carry out such work in an aircraft factory. If the preparation of the students is deficient, the instructor will be called upon to teach elementary mechanics, strength of materials, and even mathematics, if necessary. Such a lack of a mastery of the prerequisites is, however, the rule, since it is impossible for the student to acquire a complete understanding of a subject and of its applications by simply taking and passing the course. For this reason the course in aircraft structures must always begin with reviewing these subjects. The review, however, should not be a repetition. It ought to broaden the treatment of the subjects by emphasizing more completely the validity of the assumptions made, the reliability of the methods of deduction used, and the applicability of the results obtained. This pedagogically desirable practice follows quite spontaneously from the subject matter, since quite a few assumptions and routine procedures which are satisfactory in civil engineering must be discarded in aircraft structures. In order to illustrate this statement, a few examples are cited.

In aircraft structures stress calculations are carried out up to the failure of the material and not merely to stresses below the limit of proportionality. Therefore, Hooke's law is not valid.

The shape of the cross-section of a monocoque fuselage does not remain unchanged during bending. (Buckling of the covering, flattening of the section.)

A plane section through a stressed skin wing does not remain plane when a bending moment is applied to the wing. (Shear lag.)

After the review of the elementary principles, a detailed discussion of redundant structures should follow. In their treatment, preference should be given to a visualization of the distortions over a routine application of formulas. Considerable time should be devoted to the thorough explanation of the critical loads, and of the effects of transverse loads, elastic restraints, initial eccentricities and initial curvature upon slender bars in compression. The behavior of thin sheets should then be discussed in a somewhat empirical way, since the theory of plates and shells certainly cannot be included in a one year course in aircraft structures. Finally routine methods for the stress analysis of thin-walled structures should be developed. Although some of these methods are still changing from day to day they must be included in the curriculum since they represent to the young engineer an indispensable tool in his practical work.

In addition to understanding this material, the student also should be required to develop a facility for using it in the solution of practical problems. This is a difficult task to accomplish in the standard one-year period. The problem is increased by the lack of adequate textbooks. This lack is not due to the scarcity of persons competent to write such texts nor to the incompetency of those who have written them. It is caused solely by the rapidity of the development of new methods of construction and stress analysis. It is therefore prevalent in Great Britain, France and Germany, as well as in the United States.

Of the textbooks suitable for college use Klemin's "Airplane Stress Analysis," published in this country in 1929, and the classical "Aeroplane Structures" by Pippard and Pritchard, the second edition of which appeared in England in 1935, should be mentioned. The former naturally does not even attempt to deal with the special problems of thin-walled structures, and the latter devotes but one chapter to them. Younger's "Structural Design of Metal Airplanes" deals extensively with thin-walled structures, as may be anticipated from the title of the book, but, having been published in 1935, it obviously cannot contain anything about the more recent developments. The latest book on the market is the second edition of Niles and Newell's "Airplane Structures," which was published in 1938. The second volume, however, is incomplete, as stated by the authors in the introduction. A new edition containing much additional information on modern metal structures will be available

in the near future. Another forth-coming book on specific aircraft stress problems, written by Sechler and Dunn, has been announced for publication as a volume of the *Galcit* series.

Although this list is by no means complete, it is believed that there are no other books more suitable for college use. Therefore, at least up to the publication of the already announced two new books, no aeronautical structures course can be based solely upon a textbook. The best procedure seems to be to present the general and classical part of the subject with the aid of one of the textbooks mentioned and to supplement it with material on thin-walled structures based upon articles published by the N. A. C. A. or in aeronautical periodicals.

Final Considerations

Before the conclusion of this paper the question might be raised: What should be the chief motive when establishing a curriculum of aeronautical engineering and the course content in aircraft structures? In the case of a private institution operating without an endowment in an ideal democratic state, the motive should be solely the interest of the student who maintains the institution by paying tuition. Even in this idealized case, however, the course content is not uniquely determined. It should be outlined in different ways in cases when the best possible chance of immediate employment or the greatest usefulness in some specific field, or else the broadest basis for a later rise to leadership is desired. Any of these desiderata may be overwhelming, according to the financial status and psychological makeup of the individual student and according to the general economic situation of the country.

In a purely totalitarian state the desire of the individual does not count and the needs of the state are alone decisive. In actual states, as distinct from the above idealized ones, and in colleges maintained partly by state funds or by the contributions of benefactors, the issue is much more involved. Nevertheless, there can be little divergence of opinion in the United States regarding the statement that colleges should give students a training most beneficial to their development and advancement so long as this does not conflict with the overwhelming interests of the country in a national emergency.

This statement, however, implies that college education should strive to give broad bases of knowledge which will enable the student to rise to leadership in the industry. Therefore, a course in aircraft structures should stress general principles and general methods rather than give graphical or numerical procedures useful only for specific problems which in the fast development of aeronautics may become obsolete in the course of a few years. A certain amount of

factual knowledge of routine procedures is, of course, necessary both in order to develop the student's abilities for practical applications, and also to provide him with some immediate usefulness when he enters the profession. A good training, therefore, must blend in the best ratio the elements of factual knowledge with the development of the power of effective thinking. In aircraft structures this best ratio contains far more of the power of effective thinking than do the older branches of structural engineering in which the methods of construction, design, and structural analysis have become more standardized.

This paper may well be concluded by quoting Dr. Rogers' definition of the objectives of engineering education, given in an article on the "Organization and Administration of Engineering Courses" published in THE JOURNAL OF ENGINEERING EDUCATION, New Series, Vol. XVIII, No. 10, June 1928:

> The objectives of engineering education are usually expressed in terms of courses and curricula or in terms of mastery of some field of technical science or art. They are seldom expressed in terms of powers, or abilities developed in the student. The purpose of engineering curricula is, nevertheless, to train men for entrance into the profession at various levels and these men are judged and make progress more particularly because of the powers which they demonstrate than because of the knowledge they possess.

THE EDUCATIONAL VALUE OF PRE-SERVICE DEFENSE COURSES *

By EDWARD W. RUGGLES

Director, Engineering Science and Management Defense Training, N. C. State College

In dealing with the subject, Educational Value of Pre-Service Defense Courses, I will use experiences and results of these courses at State College because I believe that the faculty, students, school, and results, will not vary much from those of other institutions or localities in our section of the Country.

The E. S. M. D. T. program is to provide short courses of college grade which are designed to meet the shortage of engineers, chemists, physicists, and production supervisors, in fields essential to the national defense. It is not a general college program, but training for a specific activity. The E. S. M. D. T. program should not seriously disturb regular curricula of the Institution since persons fully trained in such curricula will continue to be needed in large numbers.

In the E. S. M. D. T. program only short courses of college grade designed to meet the shortage of engineers, chemists, physicists, and production supervisors, in fields essential to the national defense can be conducted. The courses should be designed to train for a specific activity of immediate application. Two general kinds of such courses may be offered. They are as follows:

1. Part-time courses for persons already employed either in defense or non-defense activities to give training for increased responsibility, improved technique, or new employment in fields essential to national defense.

2. Full-time courses primarily directed toward new employment but available to persons already employed in defense activities who may be assigned by their employers to take the work.

North Carolina has always been considered primarily an agricultural State though today the value of her manufactured products amounts to 1,421,329,578 dollars, as compared to 352,651,684 dollars, the value of her agricultural products. However, the three largest industries in North Carolina are the manufacture of furni-

* Presented at the annual meeting, Southeastern Section, S. P. E. E., North Carolina State College and Duke University, May 1–2, 1942.

ture, tobacco, and textiles. Consequently there are few great war industries in North Carolina.

At the beginning of the defense training program we carefully surveyed the situation with the idea of the greatest contribution State College could make. Because of the lack of large industrial centers in the State we knew that the rural areas, the small towns, and cities, contained a large number of young men who had been graduated from high school, attended one of the many small colleges in the State and were now employed in filling stations, drug stores, and the like. These men were, we felt, excellent material to train for specific defense industries. However, it would require full-time courses of approximately twelve to sixteen weeks in length with a weekly schedule of from 24 to 40 hours in class and in the laboratory.

Consequently our first program was organized and began on January 1, 1940. Courses were offered in Engineering Drawing, Architectural Engineering and Drawing, Chemical Testing and Inspection, Fabric Testing and Inspection, Materials Testing and Inspection, Instrument Men and Topographers, Diesel Engineering, Production Supervision, and Production Engineering. Applications from qualified students sufficient to fill these classes were received almost immediately after the program was announced. Since this first program, the Diesel Engineering course has been confined to Ensigns detailed to State College by the Navy. Courses in Radio Communication, Electrical Distribution, Aircraft Instruments, Airport Design, and Ultrahigh Frequency Techniques have been added.

To date we have had 2,198 students registered in full time or preëmployment courses. Every man who has completed one of these courses satisfactorily, and desired such employment, is now working in a defense industry or is in the United States Army or Navy.

There are approximately 410 men and women completing courses this month. All of them have had several opportunities to secure positions with defense industries. Personnel representatives from several large war industries have visited the campus recently and many other industries have sent application forms requesting many more men than there are available.

As for the cost of this program a check on the men who completed full time courses under the E. D. T. program showed that the cost per student hour was forty-one cents for the maximum number enrolled, fifty cents per hour for the number who completed the course, and fifty-four cents per hour for the number who received certificates. This is shown in the accompanying tabulation of all E. D. T. full time preëmployment courses.

Name of Course	Code No.	Budget	Class Hours	Max. No. Stud.	Max. Stud. Hrs.	Cost Per M. Std. Hrs.	No. Std. Compl.	Compl. Std. Hrs.	Cost Per Compl. Std. Hrs.	No. Std. Rec. Certf.	Certf. Std. Hrs.	Cost Per Certf. Std. Hrs.
Aircraft Inspection	31-3-06-011	$5,030.00	408	31	12,648	.397	28	11,424	.44	28	11,424	.44
Aircraft Inspection	31-3-24-011	4,663.00	360	26	9,360	.498	23	8,280	.56	23	8,280	.56
Airport Design	31-3-18-013	4,160.00	468	30	14,040	.296	29	13,572	.306	14	6,552	.635
Archi. Drafting	31-3-11-352	3,244.00	312	20	6,240	.519	15	4,680	.693	15	4,680	.693
Archi. Drafting	31-3-22-352	4,216.50	416	24	9,984	.422	16	6,656	.633	16	6,656	.633
Chem. Test. and Insp.	31-3-04-201	5,747.62	400	38	15,200	.378	33	13,200	.435	33	13,200	.435
Chem. Test. and Insp.	31-3-27-201	4,482.00	300	29	8,700	.515	18	5,400	.83	18	5,400	.83
Diesel Engineering	31-3-07-504	4,731.50	396	24	9,504	.497	15	5,940	.796	13	5,148	.919
Elec. Distr. Prin. and Pract.	31-3-13-306	3,296.75	450	22	9,900	.33	12	5,400	.61	12	5,400	.61
Elec. Distr. Prin. and Pract.	31-3-29-306	3,313.95	450	22	9,900	.334	11	4,950	.669	6	2,700	1.23
Engi. Drawing	31-3-01-352	2,746.20	358	25	8,950	.306	22	7,876	.348	22	7,876	.348
Engi. Drawing	31-3-14-352	2,302.46	384	24	9,216	.249	22	8,448	.272	19	7,296	.315
Engi. Drawing	31-3-35-352	1,890.00	408	26	10,608	.178	20	8,160	.23	18	7,344	.257
Engi. Drawing (W.F.)	31-3-25-352	2,475.00	450	15	6,750	.366	12	5,400	.458	12	5,400	.458
Fabric Test. and Insp.	31-3-12-901	3,220.00	384	22	8,448	.38	19	7,296	.44	19	7,296	.44
Fabric Test. and Insp.	31-3-30-901	3,257.50	420	19	7,980	.408	12	5,040	.646	11	4,620	.705
Instrument Men and Topo.	31-3-05-256	3,837.35	480	23	11,040	.348	19	9,120	.42	19	9,120	.42
Instrument Men and Topo.	31-3-16-256	3,755.00	480	28	13,440	.279	22	10,560	.356	22	10,560	.356
Mat. Test. and Insp.	31-3-03-501	6,501.45	414	39	16,146	.40	36	14,904	.436	36	14,904	.436
Mat. Test. and Insp.	31-3-17-501	5,842.02	414	27	11,178	.496	24	9,936	.587	24	9,936	.587
Mat. Test. and Insp.	31-3-34-501	5,150.00	414	27	11,178	.437	22	9,108	.565	22	9,108	.566
Prod. Engi.	31-3-09-403	2,871.00	240	24	5,760	.498	20	4,800	.598	19	4,560	.629
Prod. Engi.	31-3-20-403	3,504.50	336	22	7,392	.474	14	4,704	.745	14	4,704	.745
Prod. Super.	31-3-08-404	3,170.00	264	17	4,488	.706	11	2,904	1.09	10	2,640	1.20
Surveying (W. Forest)	31-3-26-256	2,655.00	360	22	7,920	.335	21	7,560	.35	20	7,200	.368
Chem. Test. and Insp.	31-3-15-201	4,702.50	300	17	5,100	.92	15	4,500	1.05	15	4,500	1.05
Total		100,765.30			242,622			199,818			186,504	
Average for All Courses						.41			.50			.54

One of the ways in which the educational value of the Engineering, Science, and Management Defense Training Program can be evaluated is by determining what are the characteristics of the enrollees in the various courses. Is the program attempting to instruct unemployable, maladjusted, or otherwise abnormal people? Is it attempting to deal with individuals who are incapable

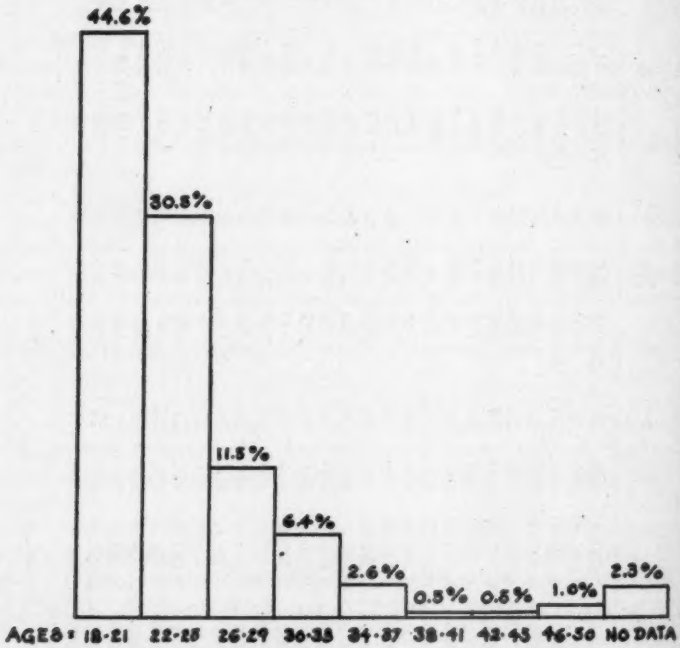

FIG. 1. Age distribution E. S. M. D. T. enrollees.

of improvement either because of lack of general ability or specific aptitudes? Do the individuals entering the program have interests so foreign to the subject matter presented that they cannot become interested in it? Are the people enrolled in the courses so constituted that they can profit from them?

In order to answer these questions, as well as to secure data which would help in the instruction and placement of the enrollee, the E. S. M. D. T. program at State College established a Division of Personnel Research at the beginning of 1942. This division has collected information concerning the enrollees who have entered

the program since January, 1942. Psychological tests of general ability, of specific aptitudes, of personality, and of interests have been administered to 1,365 enrollees at State College and at other centers throughout the State. In addition, the data submitted by each applicant on his enrollment blank are being studied and submitted to statistical treatment. The study of the results of these

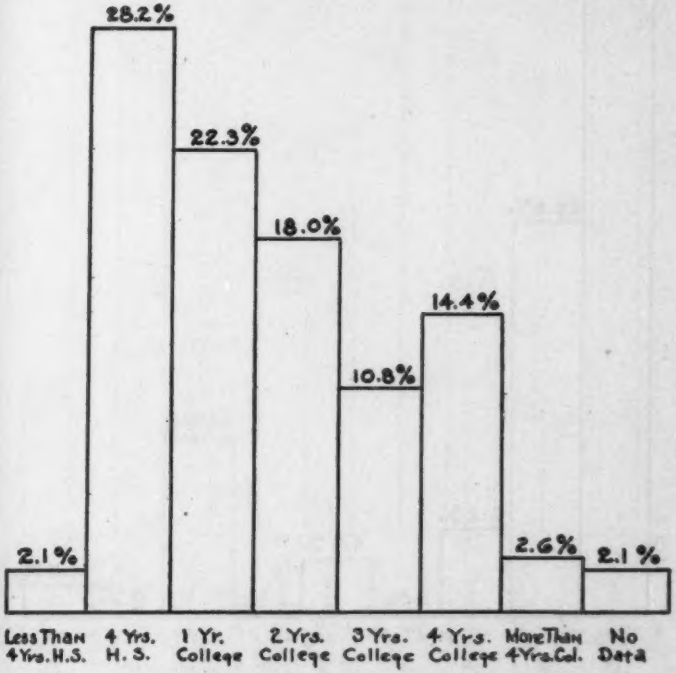

FIG. 2. Education E. S. M. D. T. enrollees.

tests, and of the personal data, is now complete on about one-fourth of these students, specifically those enrolled in courses at State College and at Wake Forest. The 390 students on whom data are available are enrolled in courses in Aircraft Inspection, Architectural Engineering, Chemical Testing, Diesel Engineering, Electrical Distribution, Radio Communication, Engineering Drawing, Fabric Inspection, Instrument Men and Topography, Material Inspection, Production Supervision, and Surveying. While it is not claimed that enrollees in other centers are essentially similar to

those in Raleigh and Wake Forest, it is believed that a study of the characteristics of these enrollees will give answers, in part, to the questions raised earlier in this paper.

Data on each enrollee were available on his enrollment card concerning age, race, sex, marital status, education, and other fac-

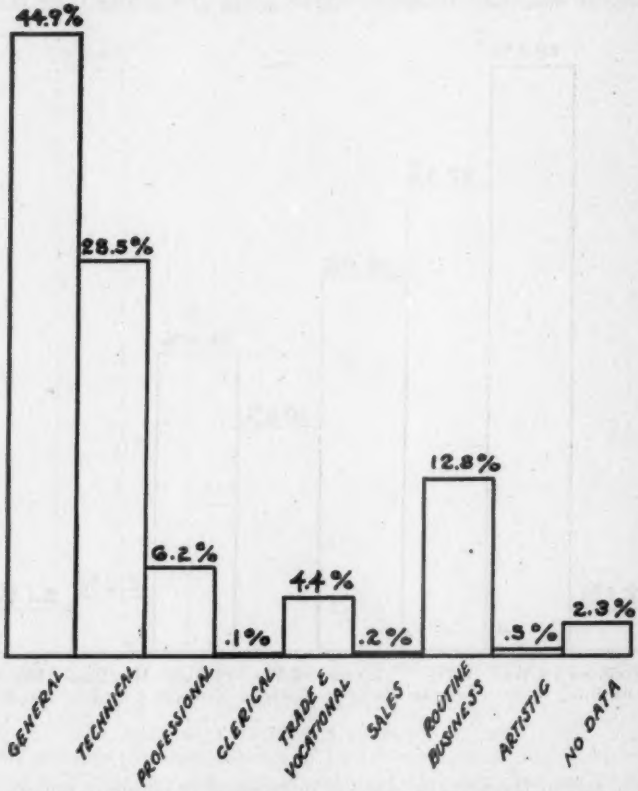

FIG. 3. Type of previous education of E. S. M. D. T. enrollees.

tors. Certain of these characteristics will be discussed before presenting the results of the psychological tests.

Three hundred and seventy of the enrollees are men, 327 of them are single and 289 of them are residents of North Carolina. Forty-five are residents of the Middle Atlantic states, while 35 come from Southern states other than North Carolina.

Thirty-eight per cent are employed, and taking the E. S. M. D. T. courses as well as working. It should be pointed out that many of the unemployed were working up to the time the courses started and quit their jobs in order to enroll.

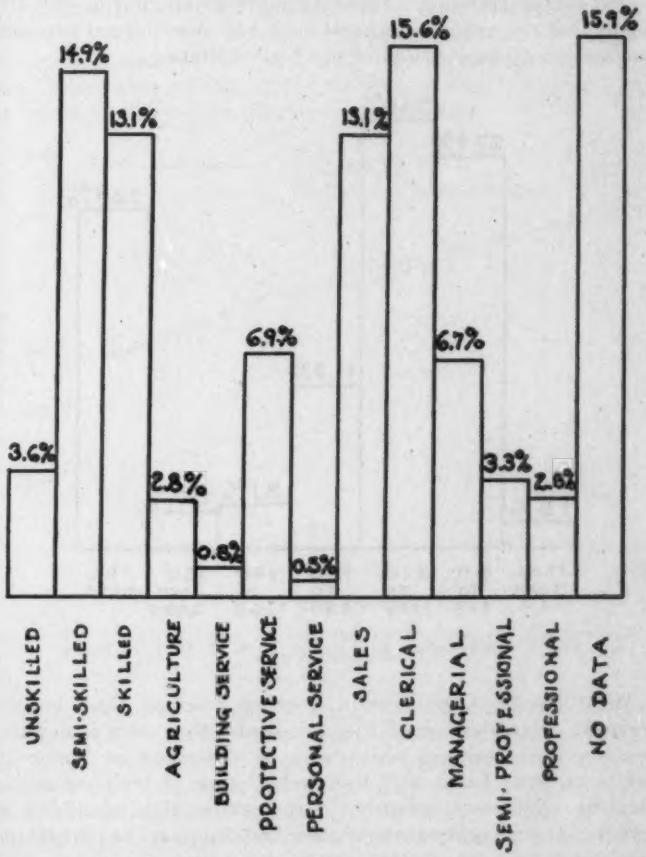

FIG. 4. Distribution by occupation of E. S. M. D. T. enrollees.

The enrollees in the group are essentially young people. Their average age is 23.4 years with a range from 18 years to 50 years. Figure 1 shows the percentage found in various age groups. Over seventy-five per cent are less than 26 years, while 44.6 per cent are less than 22 years old.

The average enrollees have had at least one year of college work. High school graduates make up 28.2 per cent out of the group; college graduates 14.4 per cent. Over two per cent have had some graduate work, while a similar number have had less than 4 years of high school training. These data are given in Fig. 2. It is evident that the group in general have had more formal education than has the average citizen of the United States.

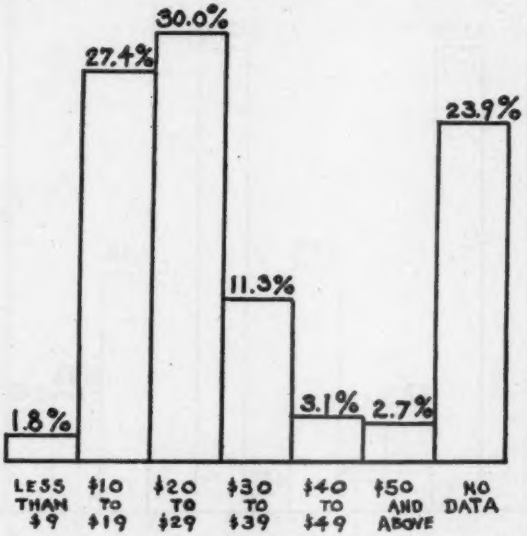

FIG. 5. Distribution of salary of E. S. M. D. T. enrollees.

What has been the type of previous training these enrollees received? Examination of Fig. 3 indicates that more than half of them received training which may be described as "general"; that is "a little Latin, and less Greek" type of training so characteristic, until very recently, of the public high schools of this section. The general nature of their training may, in part, explain their enrollment in courses which give instruction in a specific occupation. About 28 per cent had received technical training, about 4 per cent, trade training, and about 13 per cent, routine business training, in the public schools and colleges.

The occupational experience of the enrollees is varied. The largest single group reporting on their previous occupation claimed clerical work as their vocation (this in spite of the fact that the

smallest number had been trained in the schools for this sort of work). Semi-skilled occupations with about 15 per cent, and skilled and sales occupations each with 13.1 per cent are next in line. The distribution by occupations are given in Fig. 4.

The median salary of the enrollees on their last regular job or present job was $21.95 a week. The maximum salary reported by any enrollee was $175.00 per week. The largest group, 30.8 per cent, earned between $20.00 and $29.00 per week. Figure 5 gives the details of the weekly salaries of the enrollees.

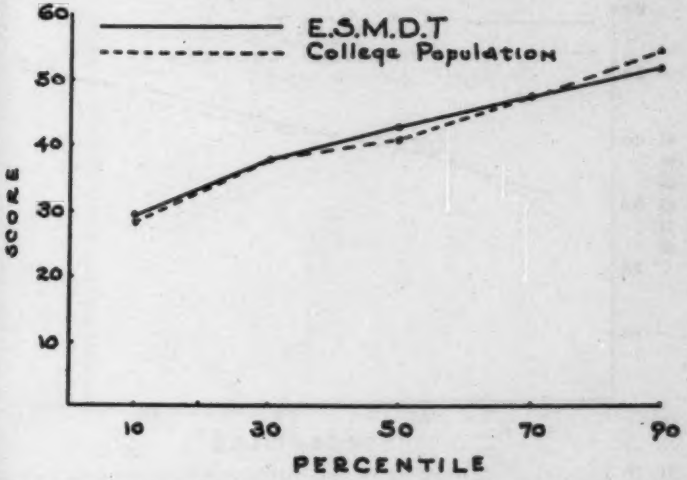

FIG. 6. Comparison of scores on Otis Intelligence Test of enrollees and college population.

In terms, then, of data collected from the enrollment cards, the enrollees are in the main young unmarried men with better than a high school education, with only general training, and when employed were working in jobs for which they were not specifically trained by the public schools. They seem, in terms of the information available, perhaps higher in educational attainment than similar unselected men, but otherwise not greatly different.

What are the characteristics of these enrollees in terms of their aptitudes, personality traits, and interest? All the enrollees were given a general aptitude test, a personality test, and an interest test. Specific aptitude tests were administered in the various curricula, but not to all enrollees. For example, in subjects involving drafting, a test was administered to measure capacity to

make spatial discriminations; in other subjects requiring the ability to learn physics, a physics aptitude test was used. Results of the tests administered to the majority of the enrollees will be discussed, both due to limitations of time, and your patience.

The Otis Self-Administering Test of Mental Ability (a so-called "intelligence" test) was used to determine the capacity of the enrollees to deal with verbal and abstract ideas. The enrollees are definitely above the general population in this capacity, their median score being 42, while that of the general population is 32.

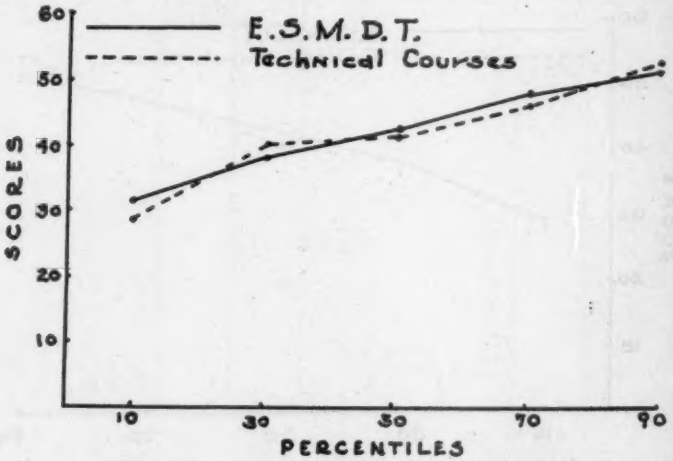

FIG. 7. Comparison of scores on Bennett mechanical Comprehension Test of E. S. M. D. T. and of technical course enrollees.

In fact, the ability of the enrollees is much more like that of college students than it is like that of unselected individuals. This clearly shows in Fig. 6 where the scores of the E. S. M. D. T. enrollees and of college students are almost identical.

One of the special aptitude tests given 142 of the enrollees was the Bennett Mechanical Comprehension test. This test samples the capacity to understand physical relations and problems. A comparison of the scores made by E. S. M. D. T. enrollees with those of candidates for technical courses is given in Fig. 7. Again the E. S. M. D. T. students do not suffer by comparison. In comparison with unselected individuals, the E. S. M. D. T. enrollees are higher on this test.

Another special aptitude test given to 155 of the E. S. M. D. T. students was the Minnesota Paper Form Board. This test meas-

ures aptitude for dealing with visual space and is a type of ability needed by draftsmen and topographers. In comparison with students enrolled in college engineering courses (Fig. 8), the E. S. M. D. T. students are slightly inferior, but again they are superior to unselected individuals.

The Bernreuter Personality inventory purports to measure emotional stability, or freedom from neurotic tendencies, feelings of self-sufficiency, and the tendency to dominate in face to face situations. A comparison of E. S. M. D. T. enrollees to adult men in

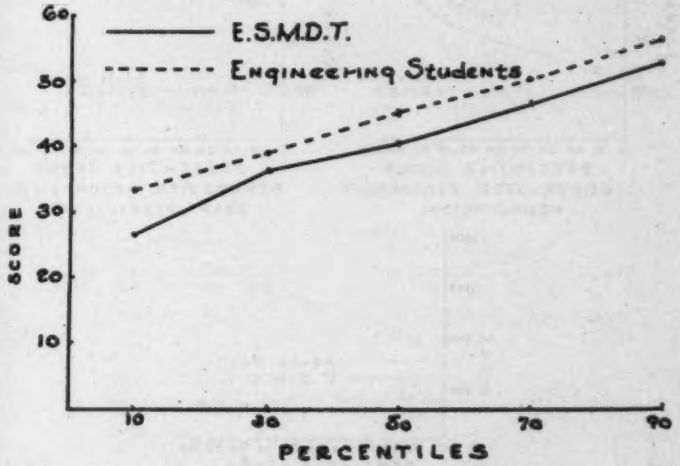

FIG. 8. Comparison of scores on Minnesota Paper Form Board of E. S. M. D. T. enrollees and of engineering students.

general on these three traits (Fig. 9), indicates that the E. S. M. D. T. students are slightly more emotionally stable, dominant, and slightly less self-sufficient than men in general. Only in the later trait, self-sufficiency, is the comparison unfavorable to E. S. M. D. T. As a matter of fact, differences are so small between the groups that they are really insignificant. Obviously, E. S. M. D. T. enrollees are as well developed in personality as the general population.

Are the interests of E. S. M. D. T. students in line with those engaged in engineering and technical occupations? Here the data indicate that the answer is no. The Strong Interest Test used in the personnel research program compares the interests of the individual tested with successful men in given occupations. Fig-

ure 10 indicates that the interests of the enrollees are more nearly those of people engaged in sales work than to any of the other five occupations (including "engineers") with which comparisons are made. It is well known, however, that interests are less stable below the age of 25 and more than 60 per cent of our group are below that age. Further interests develop through experience. It

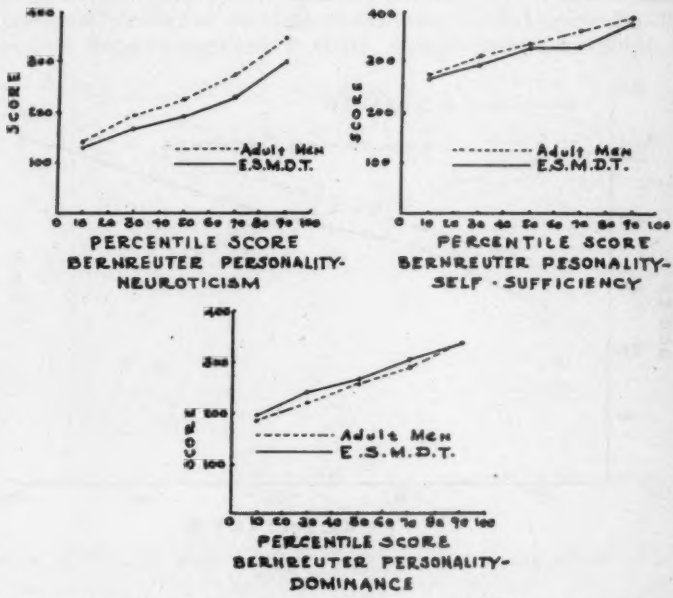

FIG. 9. Comparison of E. S. M. D. T. enrollees on neuroticism, self-sufficiency, and dominance to adult men in general.

is entirely possible that our group may develop interests in technical and engineering occupations.

On the basis of the data presented we may draw some conclusions concerning the educational values of the E. S. M. D. T. program in terms of the questions asked at the beginning of this paper. We are not training abnormal, incapable individuals. We are training individuals above the average of the general population in formal educations, general ability, and certain specific aptitudes which are probably important in learning technological subjects. They are individuals who, on certain personality traits, compare favorably with the general population. Further, we are giving

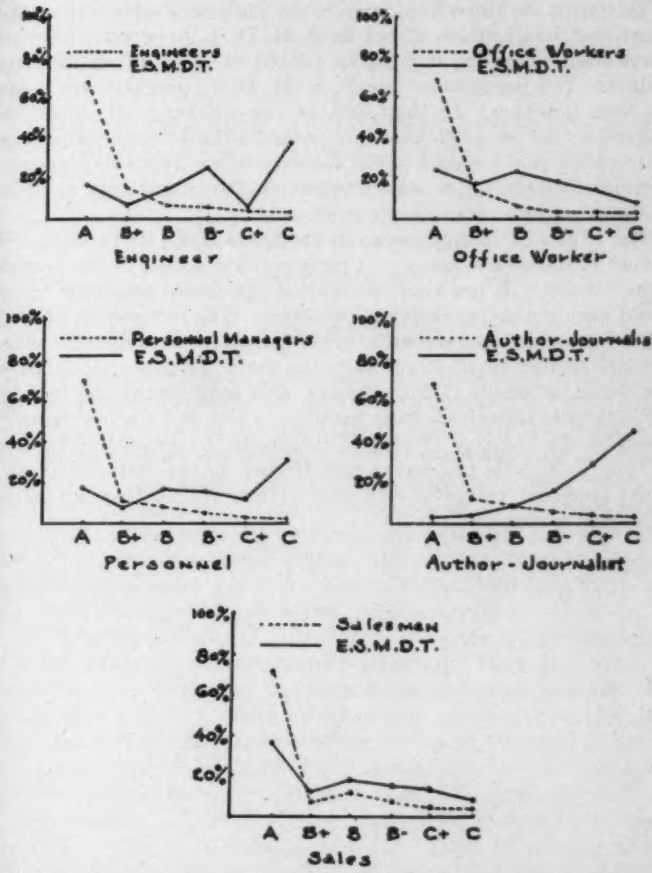

FIG. 10. Comparison of vocational interests of E. S. M. D. T. enrollees to successful people in specific occupations.

them an opportunity to receive specific job training which they were not able to secure in their earlier formal education.

It should further be pointed out that the characteristics of our group are not dissimilar to those of a much larger number of E. S. M. D. T. enrollees (over 10,000) studied by Dr. Moore in the State of Pennsylvania and described in a recent issue of the *Journal of Applied Psychology*.

This must be considered merely an indirect evaluation of the educational implications of the E. S. M. D. T. program. Like all educational endeavors, it must be judged in terms of its ultimate product. The products of the E. S. M. D. T. program are going into war industry. If they add to the efficiency of American production, the program has definite educational value. Just how to determine this I cannot say. It is a problem that even teachers of engineers have yet to solve concerning the educational value of their own engineer training programs.

The effects of this program on the Institution, its faculty, and regular students, are many. It certainly has added to the burden of the faculty. It has made additional equipment available which should improve the work for all students. The seriousness of purpose of these defense students as compared to the regular college students should be of moral value to the institutions, and lastly, I believe that many of the students who have tasted the benefits and satisfaction derived from training, which has for its primary objective, the training of men to reason, to do something, to earn a living, to be able to make a contribution to the material as well as the spiritual values of life, will return for further education after this emergency.

A PLAN FOR SPECIAL ACCELERATION OF THE STUDY FOR SENIOR ENGINEERING STUDENTS OF SUPERIOR ABILITY

By PAUL F. NEMENYI and ROBERT L. LEWIS

Colorado State College

Introduction

The recommendations of the committee on acceleration of regular engineering programs is, no doubt, going a long way towards satisfying the needs of defense industry and industrial research for thoroughly trained young men. However, one aspect of the recommendations has probably left some worried afterthoughts in the minds of the committee as well as other educators who are eager to coöperate in the United Nations' war effort, namely that this whole broad acceleration program will not increase the nation's supply of college graduates by one single person before February, 1943, that is a whole year from the date when this is written.

It is hardly possible to overestimate the practical significance of this limitation of the accelerated program. It is true that the possibility of a prolonged war, even of several years duration, cannot be discarded and has to be taken into account in all our planning; but it is hardly imaginable that the needs in engineering and allied fields, and particularly for young designers, shall become in any period of the struggle more acute than in the present year.

Particularly in such engineering activities, the results of which are indirect but indispensable prerequisites of an intensified war effort, as design and construction of large power plants and merchant ships or the developing of oil and other mineral resources, the need for great numbers of technical men is this year probably greater than in the future years, in which the fruits of present preparatory work will to a great extent be harvested.

Therefore, the writers have investigated the possibilities of adding a special proviso to the accelerated program which would make available a considerable number of able and well trained college men at the end of the summer session of the present year instead of in February, 1943.

Premises and Scope of the Suggested Plan

The basic resolution of the committee that essential contents of the curriculum should remain uncurtailed has been accepted without question by the writers, among other reasons, because a fundamental discussion of curricular content would lead too far afield. However, if the traditional method of approach and formal presentation of this curricular content also remains unchanged, hardly any acceleration of curriculum except through ommission of vacations is practicable, and in this case acceleration could not possibly go substantially beyond that proposed by the committee.

It occurred, however, to the writers that the method of presentation can and should be changed very radically for the top fifteen per cent of the students now in the junior year. This assumption is based upon experiences with gifted children and adolescents in ordinary grade and high schools and in special classes. Apart from these psychological indications also the actual demands made by engineering practice on young college graduates in our times, and particularly in the present emergency, did have to guide us in the proposed procedure. By use of certain changes in method, which will be explained and justified later, and thanks to the superior ability of the selected group, the curricular content of the whole senior year can, without any danger of overburden, be presented in a single summer term.

Individual Differences in Students.—Experiences in Rapid Promotion of Gifted Grade and High School Pupils

Probably every experienced college teacher knows that, in spite of the sifting influence of the credit and "quality point" system, even among seniors the individual differences in ability are very considerable. In state universities and state colleges, where the laws make a strict sifting at the start impossible, much of the basic differences of ability persist, in spite of students dropping out, to the end of undergraduate studies. This is true to an extent which is quite surprising, and which is found by many teachers to be detrimental to the success of their work. To be sure, individual differences in personality, in "turn of mind," in style of thinking in young people are only to the good; but great quantitative differences in intelligence, interest, and perserverance make the work of a class very difficult, and often unsatisfactory.

In spite of these facts it seems that no attempts have so far been made to establish any special classes or other measures for the benefit of gifted undergraduate engineering students. We will turn therefore to the ample material concerning gifted elementary and

high school youth, and the special measures that have been tried for their instruction. Although naturally the results concerning young children and adolescents do not permit direct conclusions for the adult young people with whom we are dealing, the results observed in the former will give us valuable indications as to what can be done and some clues concerning the method which should be followed to substantially accelerate the study of able seniors.

There are in use three major methods of assisting gifted youngsters to make the best use of the time spent in grade and high school: first, rapid promotion; second, curriculum enrichment; third, a combination of both. Although all three of these methods can be used to a certain extent within the framework of an ordinary classroom, they can be carried out much more successfully in a homogeneous, select class. Such classes are particularly valuable in connection with the latter two measures.

Dr. Whipple, who, while a professor of applied psychology at Carnegie Institute of Technology, did some pioneer research work in the field of selection and education of gifted children and youth, found the potentialities inherent in methods adapted to the abilities of gifted children much larger than was believed possible previous to his work. He wrote:

> By lessening the amount of drill, decreasing the amount of explanation, and omitting or passing rapidly over what is already known or relatively unimportant, enough time can be saved so that all of the essential topics of two years can be mastered in one. There will be time enough left, in addition, to make possible the introduction of a considerable amount of cultural material . . . by which the course will be enriched. . . .*

Since this statement was first published more than 22 years have passed. The writers have carefully read all literature accessible to them published during this period, concerning the rapid promotion of gifted grade and high school children and its effects upon their college studies. The publications examined, which are listed below,† are unanimous in the statement that rapidly promoted

* Whipple, G. M., "Selecting and Teaching Gifted Children," p. 125, First printing, Bloomington, Illinois, 1919.

† Engle, Thelburn L., "A Study of the Effects of School Acceleration Upon the Personality and Social Adjustment of High School and University Students," *Journal of Educational Psychology*, Vol. 29, pp. 522–539. "A Comparison of the Personality Traits of Three Hundred Accelerated, Normal, and Retarded Children," *1932 Journal of Educational Research*, Vol. 26, pp. 31–34. Friedrichs, Jeanette, "Too Young for College?", *Parents' Magazine*, August, 1939. Eurich, A. C., "Youth in the Colleges," *Thirty-eighth Yearbook of the National Society for the Study of Education*, pp. 74–96. Garrison, Karl C., "The School Provisions for the Gifted," *The Psychology of Exceptional Children*, Chapter 10, New York, 1940, pp. 138–153.

elementary or high school children are not in any way handicapped as to their scholastic achievements or intellectual development neither during the year in which they advance rapidly nor in the college years following thereupon. On the contrary, they continue to do work of superior quality. The statement of Whipple as to how fast gifted pupils are able to progress in their studies is unchallenged. The only drawback which, if rapid promotions follow each other swiftly totaling several years, may become a serious one is a certain emotional or social maladjustment. This, however, was found to be a consequence of developmental traits peculiar to preadolescence and adolescence, and is, therefore, entirely irrelevant in the rapid promotion of senior college students proposed here.

The Curricular Content of the Senior Year of the Engineering Course and the Way to Its Mastery in One Summer Term

The essence of the proposed arrangement is to select from the many subjects of the senior year of each department one subject, or rather a small group of subjects, which is of great practical importance to the defense industries, and in the fundamentals of which the student has already been trained in the course of his three college years. This group of subjects will presumably be his essential intellectual tool immediately after his graduation and probably for some time to come; therefore the time allotted to this group of subjects should not be reduced substantially, *i.e.*, within the special summer period the students should use almost as many hours for these studies as he normally does during seven or eight months, but in a manner adapted to his superior abilities, thus leading him far beyond the usual level in this field of specialization. All other senior subjects should be put upon a survey course and seminar basis, and the pooled time allotted to them should be not more than one third of that which is given to them in the normal seven or eight month study period.

It might be well to explain and to justify the principles underlying this plan by means of an example. In civil engineering the subjects referred to as most vital to the war effort are those connected with structures. Before entering the senior year the students will have completed mathematics, statics and strength of materials, and probably also some elementary theory of structures. In the senior year they normally take more advanced work in theory of structures, reinforced concrete, design of bridges and mill buildings, steel structures, masonry structures, foundations, or similar subjects. All these subjects should be pooled and taught intensively in one course of theory, one of lectures concerning design and con-

struction practice, an accompanying seminar, and a great deal of supervised designing activity. In this design work the student should not be required to spend a great deal of time in working routine examples of small scope, but should concentrate his efforts on three or four large realistic projects.

What are the rest of the subjects in the senior year? A glance into the catalogues of the leading engineering schools shows that they can more or less readily be divided into three groups. One group concerns civil, hydraulic, and sanitary engineering and some of the scientific fundamentals belonging thereto. Obviously subjects such as Sanitation, Railway Engineering, Tunnels, Highway Engineering, Highways and Transportation, Waterpower, Water Supply and Sewerage, Hydrology and sometimes Geology belong to this group. All these should be pooled into one single Survey Course of Civil Engineering, and one seminar belonging thereto, with only three or four hours total classwork per week. A second group of subjects leads our structural engineering students still further afield into engineering subjects outside his primary concern and interest such as Mechanical Engineering, Heat Power Engineering, Hydraulic Machinery, etc. For convenience we might combine with this group the courses designed to acquaint the civil engineering senior with economic, business, and administrative aspects of industry and public life, *e.g.*, courses entitled Contracts and Specifications, Engineering Economics, and Industrial Administration. Not all of the numerous courses mentioned will be found in any one curriculum, but the two groups of studies are distinctly present in all senior engineering curricula that the writers were able to study. This latter group of subjects should be pooled into a Survey Course of General Engineering supplemented by a Seminar of General Engineering with a total of two to four hours per week allotted to it, depending upon how much of this material has been given prior to the senior year.

The last and smallest group consists only of Public Speaking and Engineering Writing (under somewhat varying titles). These should be omitted entirely as the short discussions adjoining the lectures of the two described general courses and particularly the three suggested seminars, would give very adequate opportunity and motivation to learn the art of writing and speaking on serious subjects by practicing it.

These are then the basic possibilities of covering the semesters of civil engineering work in one summer. Although the writers do not feel competent to make detailed suggestions for rapid-promotion possibilities in other departments, they are satisfied by a study of a number of catalogues, that in most departments of engineering study, one small group of practical subjects is found which

is of considerable importance to the defense industries and in which the students have already completed all or most of the prerequisite studies. (For example: in the Mechanical Engineering Department of the University of California these subjects are Fluid Mechanics, Mechanical Engineering, and Mechanical Engineering Laboratory with a joint credit of 13 hours.) This one closely knit group of subjects should be given to the selected students in about the same number of class hours as normally, but this time should be used in a manner adapted to the superior ability of students and to the intensified and integrated method of work best suited to the training of first class specialists. All other subjects should be greatly accelerated by being fitted into the framework of two appropriate survey courses supplemented by two seminars.

We have already mentioned some major psychological and curricular considerations which underlie this plan. It is now necessary to look upon it more closely from the standpoint of present day engineering practice. The need today is certainly not for young men who know many branches of engineering superficially, but for men who are keenly interested, thoroughly trained and skilled in one single, reasonably broad branch of engineering. This does not mean that the present writers do not appreciate the value of courses outside the students' chosen field of specialization. They believe only that the instruction in these courses should be carefully adapted to the significance they have for the specialist. It seems to us that there are two distinct things they ought to accomplish for him:

First: recent psychological investigations show beyond doubt* that a broad general understanding of the main ideas of a large field of human endeavor, of which ones special interests and tasks are but a part, greatly enhances his ability and initiative in his dealing with the latter. Such a stimulating understanding of a field of engineering which is larger than what oneself can fully master, can be reached only by a broad, interesting survey combined with coöperation of the students themselves in seminar work, not by routine textbook study, recitations and examples. It can be reached in very limited time by gifted students who usually have the ability to see the special application in the mirror of the general law and vice versa, and to establish sometimes farfetched yet fruitful analogies.

Second: The surveying of various phases of engineering should provide the specialist with the main concepts and the pertaining vocabulary which will make his coöperation with other specialists better and easier. Perhaps the simplest example for the need of such coöperation is the design of a large crane, which can best be

* Bagley, W. C., "Education for Adaptability."

done by structural, mechanical, and electrical engineers in coöperation.

These suggested survey courses should therefore consist of a series of carefully coördinated lectures, some of them illustrated by moving pictures, or by visits to industrial plants, power plants, etc. This program should be made tentatively by the professor in charge in a way which will permit modifications which may be suggested by the student group. Such a tentative program for a Survey Course in Civil Engineering for a rapid promotion group of structural engineering seniors may be for example, something like this: Water: Its Occurrence in Nature (Hydrology); Water: Its Usefulness and Dangers; The Control of Water: Soil Conservation, Drainage, Flood Control; The Use of Water in Agriculture: Irrigation; The Use of Water as a Means of Communication; Water Supply; Water Power; Multiple Purpose Projects in Hydraulic Engineering; Structural Problems in Hydraulic Engineering; Structural Problems in Crane Engineering; Structural Problems in Electric Powerlines; Highway Engineering; Railway Engineering; Recent Trends and Economic Problems in Transportation Engineering; Public Hygiene and Sanitary Engineering; The Role of a Civil Engineer in Emergency Housing Projects; City Planning; Regional Planning; Recent Trends in Construction Practice.

Similarly a tentative plan for a Survey Course in General Engineering for the structural seniors might be as follows: Steel: Recent Developments in its Production and Use; Some Problems of Mechanical Engineering. First Lecture; Some Problems of Mechanical Engineering. Second Lecture; New Trends in Machine Design; The Mill Building: Some General Viewpoints for its Design; Thermodynamics and Heat Engines. First Lecture; Thermodynamics and Heat Engines. Second Lecture; Basic Principles in Electrical Engineering. First Lecture; Basic Principles in Electrical Engineering. Second Lecture; Heat Power Plants: General Viewpoints for Their Design; Hydroelectric Power Plants: General Viewpoints for Their Design; Problems of Engineering upon Which Various Specialists Coöperate; On Cranes; On the Use of Machinery in Structural Work; Engineering Literature and How to Make Best Use of It.

It will be seen that neither of these courses can be well given by one person alone. Lecture courses for the survey of such vast fields of engineering have, as far as we know, never been made. But lecture courses of a similar type are given, in other fields, at several universities. Most recognized and successful are the four large survey courses (each running through three quarters) of the University of Chicago, one covering the field of the humanities, another of the social sciences, a third one of the biological and a last one of

the physical sciences. Each of these courses is under the direction of one professor whose role is mainly the coördination of the efforts of a number of specialists. The course on physical sciences is the product of a coöperative effort of more than 15 scientists, each giving only a few lectures on his favorite field of specialized study and research. This setup combines the advantages of the unity of an integrated vista, with those of a thoroughly up-to-date and concrete representation which nobody could offer without long continued, specialized, firsthand research or experience.

The survey courses in engineering suggested here, although very broad and comprehensive, are much less so than the four Chicago courses. Probably coöperation of three to five faculty members and one or two outside speakers might be adequate for each of them.

In addition to the short discussions in direct conjunction with each lecture it was suggested that seminar work should supplement each lecture course. Here students of the group should present papers following up some of the aspects of the lecture course, or supplement it by papers on special engineering problems which could not be covered in the lectures; or they may report pertinent work experience they have had. In this seminar work the professor in charge of the corresponding lecture course should act as an advisor.

As to the work of our senior group in its vital field of specialization, the procedure suggested above represents a less radical departure from the traditional methods of instruction, because the time available for these studies would make it possible to give the usual amount of information and training even to the average students. However, in order to enable the selected group to make the best use of the rapid promotion course offered to them, their special study-attitudes and abilities should be turned to best account. We should like, therefore, to quote here a few of the many observations of Harry J. Baker,* an authority in the education of exceptional children and youth, concerning characteristics of bright pupils and how to make the best of them.

"Bright pupils are capable of abstract reasoning which consists of performing mentally processes otherwise laborious. This characteristic quality is a tremendous time saver in learning.

"Bright pupils prefer long-time units of work with greater returns rather than short, specific units with lower returns.

"They possess desirable powers of selfcriticism.

"They dislike too much concrete routine but are willing to employ a certain amount of it when they become aware of their need for it." There-

* "The Psychology of Ability Groups and Implications for Instruction Differentiation," *Thirty-eighth Yearbook of National Society for the Study of Education*, Edited by G. M. Whipple, Part I, pp. 135–160.

fore: "The interpretative aspects of all courses should soon lead to abstractions and to generalizations that open avenues of power in applying theory to practice as well as to new areas of theory."

The courses should be organized in such a way that they give opportunity for individual initiative as well as for contribution of a sub-group of students to the work of the whole group. In the light of these observations and ideas of Baker, the organization of subject matter suggested earlier in this paper will be readily understood.*

Selection of the Students for the Rapid Promotion Group

When Baker speaks of "bright" pupils he means the top 20 or 25 per cent of the school population. Other authors would restrict special methods of education and promotion to a much smaller group, the "gifted," which is defined usually as about the top 10 per cent as to scholastic ability (or as to "general intelligence" or to "abstract intelligence"). The writers do not intend to participate in the discussion of these highly controversial, and highly technical problems, nor to accept any of the technical methods suggested for the actual selection of the students for the special instruction group. As they are making a practical proposition for a plan which, if accepted in principle, has to be worked out in detail within the next three months, they have to make an easily practicable and fairly conservative suggestion. It is proposed to select primarily that well defined group of the juniors which constitute the top 10 per cent in "pertinent scholastic achievement." As "pertinent scholastic achievement" the authors define the arithmetic mean between the mean of all of the students' grades in the first three years and of those grades which are important prerequisites of his chosen field of specialization. To this group should be added, however, a smaller number of students not quite so excellent in terms of the "pertinent scholastic achievements," as the first, but known to the faculty as not only intelligent and capable of independent study, but also of persevering and careful work.

There can be, obviously, several reasons why a student possessing such fine qualities of intelligence and character falls outside

* To make the suggested plan more concrete, the following tentative plan for the time disposition of civil engineering seniors may be stated here: All morning session Monday through Friday should be given to lectures on Theory of Structure (one hour per day), on Design and Erection of Structures (one hour per day) and the rest for structural designing and computation work for the most part supervised. One afternoon two hours should be Seminar in Structures, two afternoons would be given to survey courses with the corresponding seminars (one afternoon to each), so that this class work could be occasionally replaced by an excursion. All the remaining time for study, unsupervised design work and preparation of papers for the three seminars.

the top ten per cent. Probably the most common is the economic reason, of having to work his way through college, a task which only a genius can perform without some detriment to his scholastic achievement. Second, the student may, although interested in his studies, develop such an absorbing interest in some worthwhile and truly constructive extracurricular activity, *e.g.*, building up a campus coöp that he is unable to give full intensity to his study. Third: if his intellectual power is great and his "threshold of frustration" low he may feel, as Frank Aydelotte puts it, the usual college routine to be a "lockstep" and prefer to put all his interest in some purely personal pursuit: a private study or avocation. It is obvious that after three years study the faculty is able to judge whether a student who did not make excellent grades is, notwithstanding, likely to succeed in the concentrated and rather independent work which the rapid promotion course requires. It is suggested, therefore, that to the top 10 per cent, a small group should be added, selected from among the "secondbest" 20 per cent, on the basis of confidential recommendation by those faculty members who know him personally. This group should in no case be larger than 10 per cent. The whole group would then be always between 10 and 20 per cent of the junior population, normally about 15 per cent.

Of course many other possibilities for selection exist. The authors would not insist that the one suggested is the best possibility; they only assert that general scholastic ability, special scholastic ability in fields essential for the chosen field of specialization, and strength of personality—as revealed by selfsupport or socially useful or intellectually valuable work outside the classroom —should be combined in a joint criterion of selection. Though good health and physical condition usually becomes apparent in a person's accomplishments it might be wise to give it direct attention in making the selection.

The selected students should be given the choice of this rapid promotion study or the ordinary "accelerated" course. Should any member of the rapid promotion group fail in his comprehensive examination, he should be immediately permitted to rejoin the other group, graduating in February, 1943.

It was said that the suggested selection is a conservative one. To understand this it should be remembered that all rapid promotions, the full academic success of which were referred to in an early paragraph of this paper, have taken place at grade or high school age. These rapidly promoted children were approximately the top 10 per cent of their class, and Whipple's statement on the rate at which "gifted" children can, and should proceed refers definitely to the top 10 per cent of elementary fifth grade. Junior

engineering college students are already a somewhat selected group. Therefore, even if fully 20 per cent of the graduating juniors are selected for a rapid promotion group these students can be expected to be at least as "select" and efficient a group for the particular purpose here in question, as Whipple's gifted pupils, and not merely "bright" pupils, the special teaching of whom is contemplated by Baker and some other authors.

Concluding Remarks

Even apart from economical considerations it would hardly be advisable to form rapid promotion classes smaller than five pupils, because seminar work requires for its success a sizable group, the "optimum" size probably being somewhere between 10 and 15. Therefore, unless a way is found to bring together selected students from various places in one group half of somewhat more of those students who would measure up to the above requirements, could not have the opportunity of a rapid promotion senior-study.

Even so, it appears that substantially more than 1,000 students could be graduated this September if the above plan were accepted because, although only a small number of schools could establish a rapid promotion group in each department, a very large number of schools could establish such a group in one or two departments.* With a great part of the faculty being present in the summer to conduct the ordinary accelerated courses, the proposed rapid promotion course could be easily fitted into the summer program of a faculty.

The idea, though borne entirely from the need of the moment, will perhaps be stimulating to the progress of engineering education after the war. Indeed the current system of engineering education is such that as Frank Aydelotte puts it for liberal education, "it takes care of the average student adequately, if not ideally, but is unjust to the best."

The new departure here suggested, if successfully tried out, might lead after the war to the establishment of more adequate, and therefore more just, instruction of the ablest and most independent engineering students.

* The writers made, on the basis of the statistical material concerning undergraduate engineering enrolment 1941–42 on pages 389–396 of the December issue of this magazine, a rough estimate of the total number of students to whom the rapid promotion training could be actually offered. They found that it would lay somewhere between 1100 and 1500. They checked this estimate on the basis of the statistical data on page 388 and found it well confirmed.

If students for whom such courses could not be established because of their small number, could be given encouragement and some help to join a rapid promotion course in the nearest large school, the total number could be increased easily by several hundred.

POINTING THE GRADUATES TOWARDS SUCCESS IN RAILROADING*

By J. H. COOPER

Division Engineer, Pennsylvania Railroad, Ft. Wayne, Indiana

Generally speaking, about the first serious problem that confronts a college graduate, is where he can secure employment. He has put in four or more years continuous study and has made an appreciable investment of money. He wants to realize on what he has paid for in labor and capital over a period of years. There is to begin with the uncertainty of knowing definitely how to capitalize on his investment. It is an investigated fact that the majority of engineers up until graduation do not know specifically what their future employment will be. They may follow structural, highway, contracting, bridge, railroad or many other branches of the course they have pursued, dependent on the opportunity that presents itself. While this statement has particular reference to civil engineers, it is equally true of the other engineering branches and may even cover some of the courses other than engineering. After opportunity presents itself there is a hesitancy in making a choice, due to the understandable desire to select the most advantageous opening.

In the choosing of a life's work the average technical man does not, as a rule, think of railroading. When he does select it as an occupation, it is usually because someone sells the idea to him with some persuasion. This is probably because in considering railroading, if he thinks of it at all, he does not relate it to any art or science or college education. His picture of the railroader is probably that of a rough looking individual in "overalls" with a lantern in one hand and a monkey wrench in the other. His imagination conceives an occupation that may demand some brawn, not much brain and certainly little education. In discussing a railroad career with others, if such an occasion has arisen, it may be that this work to be considered seriously as one of opportunity has been disparaged on account of hard work, small pay and limited opportunity. With such a viewpoint, it is not difficult to understand why more men do not in larger numbers decide early to follow the railroad profession;

* Presented at the 49th Annual Meeting, S. P. E. E., University of Michigan.

point toward it and equip themselves while in college to be prepared basically to start railroad work with a fundamental education that will give them a lead over the conventionally educated engineer or the practical man engaged in the same work.

The lazy individual should not think of the railroads. For the man who likes to work, with stamina and an active brain there is no industrial employment that has more attractive features. It is more than tracks and trains and stations and the men in overalls. These are only the visible aspects of the brains and resourceful science that make possible the organization that transports a nation's business. I would like to review the subject from the intimate knowledge and observation obtained from some years of personal contact with the railroads.

It has been said that there is insufficient opportunity for advancement on the railroads to warrant the ambitious college man in selecting it as an education. This statement is broad enough to challenge, and in its conclusions of sufficient importance to warrant review. It should be carefully examined both from the viewpoint of the railroads, who require the best trains available to accomplish successful management and in fairness to the college men who are entitled to the most advantageous work that their qualifications can secure. It is a well known fact that on account of competition, regulation, demands of labor, legislation and the necessity to handle a present large volume of business, there has never, in the past, been a greater incentive for men to exercise vision, ingenuity, technical skill and common sense, than today. During the early years of railroad construction many civil engineers found employment on the railroads and achieved notable successes in solving new problems. The problems of those days are multiplied many times today and their solution is an ever present opportunity to those men who have the ability, plus the desire to take them on.

The individual who can and will qualify with success has a better than average chance on the railroad, provided he is so constituted as to meet the requirements of the work. They are exacting. He cannot be a weakling. He must first of all be physically strong and mentally well balanced. He must be able to go at top speed for long periods of time and in an emergency lose sleep and rest without injury to himself. He must be mentally alert and not only receptive to new ideas, but ingenious enough to initiate fresh thought and practices. He cannot be a quitter. His mental reactions must be such as to meet adverse conditions, constructive criticism and disappointment without discouragement. He must have a mental resiliency that will not admit defeat, but that will rebound a little stronger after the experience of each failure. He must have the qualities of leadership. He must have the person-

ality that gets along with the men who work for him and those with whom he works. He need not be an honor student if he is well rounded as to all college activities.

It may be said that the qualifications I have named are unreasonable and are *not* attributes of the average college man. I believe that they *are* to a very large extent. For example, I will cite some figures that are a clear indication that the requirements I have mentioned have been present with college men on enough railroads to precisely show that such men are not a rarity. I would quote from an address by C. E. Smith, Vice-President of the N. Y. N. H. & H. R. R. Co., "Chief executives of 180,458 miles of railway, comprising the larger and more important systems in the United States, were divided as follows: (36 per cent of the mileage was headed by civil engineers; 40 per cent of the mileage was directed by college graduates in other then civil engineering; and 24 per cent of the mileage was administered by graduates of the school of hard knocks). This analysis covered 31 large railways and railway systems and 23 of the 31 chief executives were college graduates, while 8 were non-college graduates."

Mr. Smith also furnished data concerning the heads of departments on these same railways which indicated that college graduates (both technical and non-technical) headed the several departments, based on the per cent of the total mileage, as follows: accounting, 24 per cent; purchases and stores, 26 per cent; operating, 28 per cent; traffic, 31 per cent; mechanical, 47 per cent; miscellaneous departments, 47 per cent; engineering and maintenance, 84 per cent; and law, 100 per cent. On the 84 per cent of the mileage whose engineering departments were headed by college graduates, these officers were naturally all civil engineers, but in addition, civil engineers headed the operating departments on 20 per cent of the mileage, and headed miscellaneous departments on 29 per cent of the mileage.

Mr. Smith makes the further comment: "The astounding and amazing feature of the showing of civil engineers in railroading is that much less than 35 per cent of the personnel on the railroads are civil engineers. While I have no statistics to support an estimate, I would say that 5 per cent would be a very generous estimate of the proportion of civil engineers in railroading, which indicates that their chances of getting to the top have been seven times the chances of all others."

I am unable to break down these figures as to individual roads at this time, but it is of interest to know the situation on some few specific roads:

The Erie Railroad Co., one-half the higher officers are college educated.

The Southern Railway, as far back as 1914, took on a number of young college graduates in engineering with a view to giving them sufficient practical experience to justify their use as officers in the maintenance of way department. These men were first restricted to those with engineering education. This road has men now in service who are graduates in business administration. Quoting in regard to this road: "At first we had in mind the building of a reservoir of men for advancement in the maintenance of way department, but as soon as it became evident that the quality and characteristics of the men taken on were exceptionally good, the plan was soon broadened to the use of men out of this same group for advancement in the transportation department. Most of the men who have been promoted to the position of trainmaster in the past few years have come out of our student apprentice class." "When they are once supervisors their future advancement is up to them and they advance or not depending on their aptitude and ability. Out of this class we make roadmasters (or division engineers). The transportation department takes men out of our supervisor class and makes trainmasters out of them and later makes them superintendents, if they do well."

As an indication of how the apprentice system has worked out, I give the following resume of the officers on the System who have come out of that group: A vice-president in charge of operations, a general manager, an engineer maintenance of way, an engineer of bridges, ten division superintendents, seven trainmasters, eight roadmasters and thirty supervisors."

The Pennsylvania Railroad Company has as a practice for at least fifty years employed college men for training as officers. At the present time, college men fill the positions of President—Operating Vice-President—4 out of 4 Regional Vice-Presidents—3 out of 4 General Managers—8 out of 9 General Superintendents, and 19 out of 27 Superintendents. The preponderant majority of the supervisors in the N. of W. and M. of E. Depts. are college men, while the traffic and other depts. are also employing such men. These men, I believe, have succeeded and I may say that it is a matter of past and present record that this railroad has been successfully operated. It is pertinent to the question to call attention to the fact that a large proportion of the men on this road referred to, are comparatively young which is a matter of concern to the young men in considering employment.

There is one phase of this whole subject that I have not touched upon. It is that of compensation. This is of primary importance in the mind of the graduate. I say this advisedly. Twenty men, out of college from one to five years, were questioned as to what their first consideration was on finding employment. In practically

all cases the answer was money, and strange to say it was the immediate rather than the future salary that was uppermost in their minds. The feeling seemed to be that after not earning anything, in most cases, they wanted to get as much as possible at the outset, that they were young and had time to permanently place themselves at a later time.

Salaries on the railroads are to start with comparable to or slightly above those in industry generally. Those on the Penna. Railroad are increased periodically. As the individual is promoted his remuneration increases and in many cases is in excess of those in other employment. As an added financial inducement, the railroad man is assured of a substantial pension upon retirement.

There is another consideration on which earning capacity and advancement are largely dependent. That is how well a man likes the work he is doing. To most of us on the railroad and to many in other lines of endeavor, railroading holds a peculiar fascination. To men generally, a railroad is something alive, active and vital. To the railroad man himself, the work does not produce a dull life. It is filled with change and variety. It is not passive. It is a constant challenge to effort and ingenuity. It does not get into the rut of routine. There is a constant conflict with the elements, and those things that can go wrong with machinery and the team work of men. There is a sharpening of wits to figure how far a dollar can be stretched and the satisfaction of developing original ideas. There is on the railroad the appeal that exists in any game where skill is brought into play to secure a result. To the man so constituted as to enjoy competition and the satisfaction of doing things, railroad work is agreeable.

Many like positions of authority. They enjoy the directing of others. There is an understandable pride in leadership. The opportunity for this presents itself to the railroad officer. He also, as a railroad officer, automatically assumes a certain prominence in his community. As a railroad man he stands for the railroad he represents and his railroad usually ranks among the largest industries in his territory. The prestige of position is something that cannot be entirely discounted.

Summarizing, we may say that the college graduate seriously taking up railroading may expect a permanent position with advancement at a better than average compensation together with agreeable work in a respected occupation with that activity which results in happiness.

ENGINEERING ECONOMY PAGE

Engineering Economy deals with comparisons between technical alternatives in which the differences between the alternatives are expressed as far as practicable in money terms.

PAUL T. NORTON, JR., Virginia Polytechnic Institute, *Editor*

Continuing the policy of publishing problems which illustrate various aspects of the general subject of Engineering Economy, we are presenting in this issue a number of problems from "Plant Production Control," by C. A. Koepke, published by John Wiley & Sons.

Please send the editor problems which you think would be helpful to other teachers of the subject, and please also send your suggestions with regard to the best methods to use in class in explaining the problems presented in this issue and in the issue of May, 1942.

The editor will welcome any suggestions that may occur to any reader of the Page with regard to the four Pages which we should publish during the college year 1942–43.

1. If a salesman were careless with a company car and caused damage of $150, how much extra goods would he have to sell to pay for the damage if the business had been earning a net profit of 6 per cent?

2. A company has a policy of giving, for one year, 50 per cent of the extra profit resulting from a suggestion of an employee. If a man devises methods of reducing waste by $1,400 per month, how much payment is he entitled to if the company is earning 7 per cent net?

3. If an employee of the company described in problem 2 proposes a new method of assembling an article which would save $250 per month, how much should the employee receive, if earnings are 8 per cent net and if the new method will require apparatus costing $450? Assume present production schedules are contracted to run for eighteen months in the future.

4. Tools estimated to cost $411 are needed to reduce the cost of assembling a certain product. These tools would reduce the labor cost by $3.14 per hundred pieces of the product, and 21,000 pieces are used per year, with a stable demand. Burden is 80 per cent in this department. Can the expenditure be justified?

5. The cost of issuing a manufacturing order in a certain shop is $4.80. Setup costs on the five operations necessary to produce part 438 are $8.70, $3.22, $0.10, $28.60, and $15.80 respectively. The part can be produced at the rate of 450 units per day and is used at an average rate of 75 units per day during the summer season from May through August. Material costs $0.80 per unit, labor $0.06 per unit, with overhead 250 per cent of the payroll. Rental value of the storage space needed to store one unit is 1.25 cents per year. A safety factor of 10 per cent is necessary. Taxes and insurance on inventory are 2½ per cent per year. Capital earned 12 per cent last year in this company. What is the economic lot size for part 438?

6. If part 438 of problem 5 is used at an average rate of 15 units per day from September through April, what effect would this change in the rate at which the part is used have on the economic lot size?

THE T-SQUARE PAGE

DEVOTED TO THE INTERESTS OF THE
DIVISION OF ENGINEERING DRAWING

WILLIAM E. STREET, Editor,
Agricultural and Mechanical College of Texas

DRAWING DIVISION PROGRAM OF S. P. E. E., 50TH ANNUAL MEETING

SATURDAY, JUNE 27TH

12:00 Noon — Luncheon. Business Meeting.

2:00 P.M. — First Conference Session:

1. Practical Application of Descriptive Geometry in the Shipyard Drafting Room. Speaker—Mr. A. M. Merrill, Principal Naval Architect, U. S. Navy Yard, Brooklyn, New York.
2. The Application of Descriptive Geometry in the Aircraft Drawing Room. Speaker—to be announced.
3. Reports of Standing Committees.

7:00 P.M. — Drawing Division Dinner. Speaker—Mr. George Titterton, Assistant Chief Engineer, Gruman Aircraft Engineering Corporation.

MONDAY, JUNE 29TH

Second Conference Session:

1. Revision of Drafting Standard Z–14.1 and its relation to War Production. Speaker—Professor Thomas E. French.
2. Pertinent Points from the National Survey of Engineering Drawing. Speaker—Professor R. P. Hoelscher.
3. Reports of Standing Committees.

The drawing teachers are among the first engineering teachers to come in contact with freshmen engineering students, and they should be able to give students a good foundation in the engineer's language—drawing. These teachers should be leaders and inspire students to become engineers. They can be of material assistance in teaching their students systematic study habits, to be neat and accurate, to think for themselves, and to understand that engineers must be capable of taking responsibility and directing people if they are to be successful.

The cognition of this responsibility has created a desire on the part of drawing teachers for graduate courses in Engineering Drawing and related subjects to be sponsored by a university located in an industrial center. Such courses would permit teachers to improve themselves in their chosen field of work and receive credit toward advanced degrees.

Such courses might include theory courses in Engineering Drawing, Descriptive Geometry, Machine Drawing, Methods of teaching various drafting courses, the imparting of a desire on the students' part to become engineers, etc. Dr. Clair V. Mann of the Missouri School of Mines and Metallurgy, Rolla, Missouri, has devoted considerable thought to the possibility of these graduate credit courses, and has some good ideas about the establishing of such work.

SECTIONS AND BRANCHES

Michigan Section.—The annual meeting was held at the Horace H. Rackham Educational Memorial Building, 100 Farnsworth Avenue, Detroit, May 2, 1942, under the auspices of the College of Engineering of the University of Detroit in the quarters of the Engineering Society of Detroit observing the Tercentenary of Sir Isaac Newton, Professor L. G. Miller, Michigan State College, presiding. Reverend George J. Shiple, S.J., Secretary, Board of Trustees, University of Detroit, extended greetings.

The purpose of the afternoon session was to consider the changing over of Michigan industries to war production, and how E. S. M. D. T. courses could be revised to keep in step with such changes.

O. F. Carpenter, Associate District Representative, Training Within Industry, War Production Board, discussed the subject: "What is Happening in the Changing Over of Michigan Industries." The speaker discussed the War Production Board and its Aims. The presentation of changes in industries particularly in the Southeastern Michigan area embraced the place of the engineer in the selection and installation of new equipment and his development of new methods and processes. A revealing explanation was made of just how present personnel is being trained to produce entirely different products and of an entirely different character of materials in War Production. Reference was made to priorities and their effects on products for civilian and for war needs.

The speaker spoke at length on the subject of the part played by the engineer in designing new types of dies, jigs and fixtures to meet new requirements. Reference was made to the method of selection of industries formerly making civilian equipment who could use present personnel and materials in producing war material. Illustrations were cited in the difficulties of applying automotive methods to tank production, automobile body design technique to the design of airplanes, and to the new techniques in production for war which resulted in increased production. An outstanding example being the building of boats bottom side up, and the resultant cutting of production time by one-half.

The program which is under way within industry trains men who have been building automobiles to produce tanks, guns, and planes. New techniques in airplane construction have reduced construction time by more than two-thirds.

Engineers using new methods in producing munitions of war are responsible for the unusual acceleration of the whole production programs. More engineers are needed. They are needed, if we are to win the war, for while the men fighting on every front are the only ones who can win the war, we in the production centers can lose it! All the energy, all the will-power, and the skill of men will be needed if conversion to a war basis is really accomplished. Production operators must be made of N.Y.A. men and W.P.A. workers, and upgrading within industry must continue.

The subject "Revising of E. S. M. D. T. Courses to Keep in Step with Changing Michigan Industry" was presented by Professor Robert H. Sherlock, University of Michigan. Professor Sherlock pointed out that the Industrial District of Southeastern Michigan is distinctive because of its automotive emphasis, and because of the large number of small feeder plants, which take on some of the quality of the larger plants. Probably the proportionately smaller number of E. S. M. D. T. students in this area can be traced to less need of preëmployment training. But six colleges in this district have offered E. S. M. D. T. Courses, which has been largely of a part-time nature, and which have aided greatly in upgrading within industry. The great demand is from in-service men. There is an increased demand for courses to meet a specific need. For example, members of ordnance courses are recruited for the civil service. Men are trained in ultra high frequency techniques, particularly for lieutenants of army and ensigns of the navy. Emphasis will probably be more and more on these types of courses.

Wayne Stettbacher discussed the subject "Special Personnel Problems Resulting from Changes in Michigan Industry," stating that conversion to war industry included new and revolutionary changes in the character of alloys, and in heat treating. One personnel problem was that involved in welding of armor plate, the technique of which was new. Conversion has caused some industries to shrink or disappear. Sales and advertising departments of automotive concerns have been affected, so have painters, trimmers and others. Special skills must be taught for special machines required in war production.

Men will be needed in ever-increasing numbers in machine repair, arc and gas welding, tool grinders, set-up men, tool and die makers, cutter grinders, tool process engineers, die sinkers and metal pattern makers. The conversion has been so successful in the short time it has been underway that but 8000 more men will bring Detroit industry to its all time high.

An inspection trip through the new Horace H. Rackham Educational Memorial and tea at the residence of Mrs. C. J. Freund were enjoyed by the ladies during the afternoon. A dinner was served at 6:15 P.M. to S. P. E. E. members and ladies.

A symposium observing the Tercentenary of the birth of Sir Isaac Newton was presented. Four students of the Chapters of Tau Beta Pi and Sigma Rho Tau discussed the following subjects.
"Newton's Career"—John Allen.
"Newton and Physics"—Hubert J. McAuley.
"Newton and Mathematics"—Richard F. Brennan.
"Newton's Influence on Engineering"—Edward J. Nesbitt.

The following officers were elected for the ensuing year: Chairman, R. A. White, Grand Rapids Junior College; Vice-Chairman, C. C. Winn, Detroit Institute of Technology; Secretary-Treasurer, C. A. Brown, General Motor Institute of Technology.

A meeting of the **Michigan State College** Branch was held May 12, with the Chairman, O. W. Fairbanks, presiding. The minutes of the meeting of April 2 were read by the Secretary, L. S. Foltz; and approved. S. S. Radford, Chairman of the Membership Committee, explained the membership blanks and distributed them. On request, the Secretary read the Constitution and By-laws of the M. S. C. Chapter.

The Chairman asked E. E. Kinney, Chairman of the Program Committee, to take charge and the following four topics were discussed, viz.,
Industry's opinion of the engineering graduates of M. S. C.
The engineering students who fail along the way—66 per cent of those entering.
Teaching efficiency.
Entrance examinations for engineers.

I. B. Baccus, moved for M. M. Cory, who was then absent, that the Constitution and By-laws be temporarily set aside and the present officers elected to continue through the school year '42–'43. Seconded by G. M. Pratt. Carried.

L. S. Foltz,
Secretary.

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